
RISING
SEAS

1
00:00:04,338 --> 00:00:05,205
>> MICHELLE: Hello
and welcome to

2
00:00:05,205 --> 00:00:06,807
NASA Goddard Space
Flight Center.

3
00:00:06,807 --> 00:00:07,774
Today we're going
to talk about

4
00:00:07,774 --> 00:00:09,543
one of the most compelling
issues of our day,

5
00:00:09,543 --> 00:00:10,677
sea level rise.

6
00:00:10,677 --> 00:00:12,813
And with me is
Dr. Tom Wagner,

7
00:00:12,813 --> 00:00:15,816
the Program Scientist for the
cryosphere at NASA headquarters.

8
00:00:15,816 --> 00:00:17,251
>> TOM WAGNER: And today,
we're going to take you

9
00:00:17,251 --> 00:00:19,753
right behind the frontlines
of sea level rise research,

10
00:00:19,753 --> 00:00:21,488
out into the field
with the researchers,

11

00:00:21,488 --> 00:00:22,756
and here's what we're
going to be talking about

12
00:00:22,756 --> 00:00:24,091
for the next hour.

13
00:00:24,091 --> 00:00:30,097
■[Music]■

14
00:01:33,727 --> 00:01:35,062
>> TOM WAGNER:
So the big thing is this.

15
00:01:35,062 --> 00:01:37,831
Around the world,
sea level is rising.

16
00:01:37,831 --> 00:01:40,367
It's going up by three
millimeters a year.

17
00:01:40,367 --> 00:01:43,770
In the last 20 years it's
gone up by three inches.

18
00:01:43,770 --> 00:01:46,840
And, we're trying to
understand kind of why that is.

19
00:01:46,840 --> 00:01:49,076
But more importantly,
we're trying to project out,

20
00:01:49,076 --> 00:01:51,878
you know, where it's going to
be in the next hundred years.

21
00:01:51,878 --> 00:01:53,013
Like it or not,

22
00:01:53,013 --> 00:01:55,749
already the East Coast of
the US is seeing flooding

23
00:01:55,749 --> 00:01:57,217
from sea level rise.

24
00:01:57,217 --> 00:01:58,685
It's things like
the big storms

25
00:01:58,685 --> 00:02:01,288
that hit New York and
New Jersey, Katrina.

26
00:02:01,288 --> 00:02:03,290
But even in places like
the Kennedy Space Center,

27
00:02:03,290 --> 00:02:05,192
we're seeing tremendous
amounts of erosion.

28
00:02:05,192 --> 00:02:07,427
They've gone as far
as to make a map

29
00:02:07,427 --> 00:02:09,129
of areas that they
are going to lose.

30
00:02:09,129 --> 00:02:11,865
The City of Miami is
getting routine flooding.

31
00:02:11,865 --> 00:02:13,834
Now, you might say,

32

00:02:13,834 --> 00:02:17,437
"Well, you know, three inches in
20 years, what's the big deal?"

33
00:02:17,437 --> 00:02:20,307
We can probably deal with
what we've already seen, right?

34
00:02:20,307 --> 00:02:22,509
But you know, the thing
that we're worried about

35
00:02:22,509 --> 00:02:25,679
is that as you project
out a hundred years,

36
00:02:25,679 --> 00:02:29,750
it could be more like three
feet, four feet, five feet,

37
00:02:29,750 --> 00:02:32,452
and the way that society
responds to that,

38
00:02:32,452 --> 00:02:34,955
the costs rise exponentially.

39
00:02:34,955 --> 00:02:35,856
>> MICHELLE: And
one of the things

40
00:02:35,856 --> 00:02:37,991
we're going to talk a
lot about today is ice,

41
00:02:37,991 --> 00:02:40,293
and talk to us about
why ice is so important

42
00:02:40,293 --> 00:02:42,129

in the topic of
sea level rise.

43
00:02:42,129 --> 00:02:43,630
>> TOM WAGNER:
Yeah. So in general,

44
00:02:43,630 --> 00:02:45,832
the rise that we're seeing
today comes from two places.

45
00:02:45,832 --> 00:02:47,901
One, as the
ocean warms up,

46
00:02:47,901 --> 00:02:50,637
it expands just like
hot air in a balloon.

47
00:02:50,637 --> 00:02:52,406
But also, two,
the big ice sheets,

48
00:02:52,406 --> 00:02:55,308
the glaciers of Greenland
and... of Greenland...

49
00:02:55,308 --> 00:02:57,477
the glaciers of
Canada and Alaska,

50
00:02:57,477 --> 00:02:59,746
the big ice sheets of
Greenland and Antarctica,

51
00:02:59,746 --> 00:03:02,249
they are waking up and
spitting ice into the ocean

52
00:03:02,249 --> 00:03:04,017

and that's the other
half of sea level rise.

53
00:03:04,017 --> 00:03:06,053
>> MICHELLE: And so, we're going
to be bringing in Josh Willis

54
00:03:06,053 --> 00:03:07,654
from the
Jet Propulsion Laboratory.

55
00:03:07,654 --> 00:03:09,256
And then we also
have Vena Chu

56
00:03:09,256 --> 00:03:11,291
who is at the University
of California, Berkeley.

57
00:03:11,291 --> 00:03:12,826
And I believe
that's Larry Smith

58
00:03:12,826 --> 00:03:16,063
from the University of
California, Los Angeles.

59
00:03:16,063 --> 00:03:19,599
>> JOSH WILLIS: Well, sea level
has been rising pretty steadily

60
00:03:19,599 --> 00:03:23,236
in the last 23 years
around the globe,

61
00:03:23,236 --> 00:03:26,606
and we've been measuring
this with Satellite Altimeters

62
00:03:26,606 --> 00:03:30,610

with our colleagues in the
French Space Agency, CNES,

63
00:03:30,610 --> 00:03:32,612
ever since 1992.

64
00:03:32,612 --> 00:03:35,382
And the net rate
of sea level rise

65
00:03:35,382 --> 00:03:37,784
is about three
millimeters per year,

66
00:03:37,784 --> 00:03:40,253
which works out to
about an inch a decade.

67
00:03:40,253 --> 00:03:44,424
And, it's interesting because
the rise isn't equal everywhere.

68
00:03:44,424 --> 00:03:48,628
In fact, in places like the
West Coast of the United States,

69
00:03:48,628 --> 00:03:51,498
sea level has actually
been falling very slightly,

70
00:03:51,498 --> 00:03:54,868
and this is because of the
natural cycles in the ocean

71
00:03:54,868 --> 00:03:58,805
and the way the oceans and
winds can push heat around

72
00:03:58,805 --> 00:04:00,474
and redistribute it

across the planet.

73
00:04:00,474 --> 00:04:03,810
So sea level rise is
actually not all that level.

74
00:04:03,810 --> 00:04:05,112
>> TOM WAGNER:
Yeah, but Josh, like,

75
00:04:05,112 --> 00:04:06,980
but... overwhelmingly, right?

76
00:04:06,980 --> 00:04:09,082
The total amount of sea
level rise that we've seen,

77
00:04:09,082 --> 00:04:11,551
say, in the 28th century
versus the last 20 years,

78
00:04:11,551 --> 00:04:12,552
what's it like?

79
00:04:12,552 --> 00:04:14,287
>> JOSH WILLIS: Sea
levels have increased.

80
00:04:14,287 --> 00:04:16,823
The rate of rise has
increased incredibly

81
00:04:16,823 --> 00:04:19,493
in the last hundred
years or so.

82
00:04:19,493 --> 00:04:21,061
In the early 1900s

83

00:04:21,061 --> 00:04:23,563
we were looking at about
one millimeter per year.

84
00:04:23,563 --> 00:04:26,666
In the 1950s it was more like
two millimeters per year,

85
00:04:26,666 --> 00:04:28,869
and now it's three
millimeters per year.

86
00:04:28,869 --> 00:04:31,838
And, in fact, if you
look back even farther,

87
00:04:31,838 --> 00:04:33,507
the last 2,000 years

88
00:04:33,507 --> 00:04:36,109
have had almost no
sea level rise whatsoever.

89
00:04:36,109 --> 00:04:39,312
So we've pushed the Earth
into a brand-new regime

90
00:04:39,312 --> 00:04:41,882
and sea level rise
is now the norm.

91
00:04:41,882 --> 00:04:43,183
>> TOM WAGNER: Can you tell
us a little bit, though?

92
00:04:43,183 --> 00:04:45,352
And I know Michelle was asking
about this before we started.

93
00:04:45,352 --> 00:04:47,387

How do we actually
get to those numbers?

94
00:04:47,387 --> 00:04:48,421
Like you were talking about,

95
00:04:48,421 --> 00:04:49,756
how do we know
what sea level rise was

96
00:04:49,756 --> 00:04:51,792
in the 1800s or the 1700s?

97
00:04:51,792 --> 00:04:54,261
I mean today, you've pointed out
we have this radar altimeters

98
00:04:54,261 --> 00:04:55,595
that measure the
height of the ocean,

99
00:04:55,595 --> 00:04:57,130
but what are the
other ways we know?

100
00:04:58,899 --> 00:05:00,801
>> JOSH WILLIS: Well, we've
had tide gauge records

101
00:05:00,801 --> 00:05:02,469
for 150 years,

102
00:05:02,469 --> 00:05:04,204
in a few places,
even longer.

103
00:05:04,204 --> 00:05:07,741
But in the
last 2,000 years

104
00:05:07,741 --> 00:05:11,178
we've actually been keeping
a record of sea level rise

105
00:05:11,178 --> 00:05:14,881
in the sediments in places
like North Carolina.

106
00:05:14,881 --> 00:05:16,917
There's a salt marsh there

107
00:05:16,917 --> 00:05:20,954
and it turns out that the land
there is steadily sinking,

108
00:05:20,954 --> 00:05:22,422
just very slightly.

109
00:05:22,422 --> 00:05:24,624
And as the water
creeps up the land,

110
00:05:24,624 --> 00:05:26,293
it leaves behind a record

111
00:05:26,293 --> 00:05:29,496
in the form of tiny
little bugs and critters,

112
00:05:29,496 --> 00:05:32,232
uh, that die and live
in the sediment.

113
00:05:32,232 --> 00:05:34,601
So, uh, people drilling
sediment cores

114
00:05:34,601 --> 00:05:37,070
have actually been

able to reconstruct

115
00:05:37,070 --> 00:05:41,107
a very accurate sea level record
for the last 2,000 years.

116
00:05:41,107 --> 00:05:45,946
And, what it shows is not
much until the last 150,

117
00:05:45,946 --> 00:05:48,148
and that's when sea level
rise really took off

118
00:05:48,148 --> 00:05:51,618
and we began to see the
rates we have today.

119
00:05:51,618 --> 00:05:52,452
>> MICHELLE:
Now, one of the things

120
00:05:52,452 --> 00:05:53,453
I think people aren't aware of

121
00:05:53,453 --> 00:05:55,622
is just how many
resources NASA has

122
00:05:55,622 --> 00:05:57,591
to study what's
changing on the Earth.

123
00:05:57,591 --> 00:05:58,491
Uh, I think that right now

124
00:05:58,491 --> 00:06:00,427
there are actually about
19 different space crafts

125
00:06:00,427 --> 00:06:01,528
that are orbiting the Earth

126
00:06:01,528 --> 00:06:02,529
taking readings
from everything

127
00:06:02,529 --> 00:06:04,731
about the oceans, the land,
and the atmosphere.

128
00:06:04,731 --> 00:06:06,766
What are some of the missions
that you specifically work with

129
00:06:06,766 --> 00:06:08,668
and... and what are some
of the data that you take?

130
00:06:10,770 --> 00:06:12,873
>> JOSH WILLIS: Well, the
best mission of all those

131
00:06:12,873 --> 00:06:15,942
is the Jason Missions,
in my humble opinion,

132
00:06:15,942 --> 00:06:17,777
because those are the
ones that I work on.

133
00:06:17,777 --> 00:06:19,846
But, uh, I think,
uh there's...

134
00:06:19,846 --> 00:06:21,781
as you say, there is a
whole bunch of missions.

135

00:06:21,781 --> 00:06:23,149
The Jason Missions

136
00:06:23,149 --> 00:06:25,719
measures sea level
directly from space,

137
00:06:25,719 --> 00:06:27,087
uh, missions like GRACE

138
00:06:27,087 --> 00:06:30,991
actually weigh the continents
and the oceans.

139
00:06:30,991 --> 00:06:32,692
>> MICHELLE: Yeah, that's
really excellent stuff,

140
00:06:32,692 --> 00:06:34,361
you know, and the GRACE
Mission that you mentioned

141
00:06:34,361 --> 00:06:36,763
is one of the things that
I find really compelling

142
00:06:36,763 --> 00:06:38,365
that, in fact,
there's so much water

143
00:06:38,365 --> 00:06:39,666
melting off these glaciers,

144
00:06:39,666 --> 00:06:42,202
it's actually changing the
gravity field of the Earth.

145
00:06:42,202 --> 00:06:43,270
I mean, could you tell
us a little bit about

146
00:06:43,270 --> 00:06:46,172
how GRACE works and how
that measurement is made?

147
00:06:46,172 --> 00:06:47,474
>> JOSH WILLIS: Yeah,
GRACE is really fun.

148
00:06:47,474 --> 00:06:50,677
Uh, in fact, um, it's
made of two satellites.

149
00:06:50,677 --> 00:06:52,779
Uh, they are named
Tom and Jerry

150
00:06:52,779 --> 00:06:54,814
and they chase
each other around,

151
00:06:54,814 --> 00:06:57,651
and whenever the first one
goes over something heavy,

152
00:06:57,651 --> 00:07:01,187
the pull of gravity causes
it to speed up just slightly.

153
00:07:01,187 --> 00:07:03,290
And the two satellites
actually measure

154
00:07:03,290 --> 00:07:05,091
the distance
between each other

155
00:07:05,091 --> 00:07:08,361
and you can use that
information to infer the mass

156
00:07:08,361 --> 00:07:10,530
of the thing
you're flying over.

157
00:07:10,530 --> 00:07:12,265
>> TOM WAGNER: Hey, Josh!
I got a question yesterday

158
00:07:12,265 --> 00:07:13,433
from a reporter.

159
00:07:13,433 --> 00:07:14,934
Can you just talk
a little bit about,

160
00:07:14,934 --> 00:07:18,371
okay, look, the radar
altimetry, the record we get

161
00:07:18,371 --> 00:07:20,173
and how we see things
like tide gauge,

162
00:07:20,173 --> 00:07:22,776
how do they work and how
does that all come together?

163
00:07:22,776 --> 00:07:24,177
>> JOSH WILLIS:
Yeah, well, uh,

164
00:07:24,177 --> 00:07:27,447
so the satellites that measure
sea level are really amazing.

165
00:07:27,447 --> 00:07:28,682
They're 800 miles up

166

00:07:28,682 --> 00:07:31,751
and they can measure
the level of the ocean

167
00:07:31,751 --> 00:07:35,422
in a... in about a
six-mile footprint

168
00:07:35,422 --> 00:07:38,458
with an accuracy of
just one inch or better.

169
00:07:38,458 --> 00:07:40,660
>> JOSH WILLIS: So it's an
incredibly accurate

170
00:07:40,660 --> 00:07:41,828
piece of equipment.

171
00:07:41,828 --> 00:07:45,231
Um it measures the entire
planet once every ten days.

172
00:07:45,231 --> 00:07:47,400
And by averaging all
of that data together,

173
00:07:47,400 --> 00:07:48,768
we can actually,

174
00:07:48,768 --> 00:07:51,404
uh, get an estimate of the
total level of the ocean,

175
00:07:51,404 --> 00:07:53,073
the total volume
of the ocean,

176
00:07:53,073 --> 00:07:55,642
with an accuracy of

about half a centimeter,

177
00:07:55,642 --> 00:07:57,544
so it's really tiny.

178
00:07:57,544 --> 00:08:01,648
And they're really incredibly,
accurate at these missions.

179
00:08:01,648 --> 00:08:02,849
In fact,

180
00:08:02,849 --> 00:08:07,320
we've often compared
them with tide gauges.

181
00:08:07,320 --> 00:08:08,955
So in a few key locations,

182
00:08:08,955 --> 00:08:09,956
we have tide gauges

183
00:08:09,956 --> 00:08:13,960
that have been running for the
entire 23-year long record

184
00:08:13,960 --> 00:08:17,797
and they've allowed us to
help, tie together

185
00:08:17,797 --> 00:08:19,866
one satellite after another.

186
00:08:19,866 --> 00:08:22,936
We've also been lucky enough
to have each satellite survive

187
00:08:22,936 --> 00:08:24,571
until the next

one was launched.

188
00:08:24,571 --> 00:08:27,474
So beginning with
TOPEX/Poseidon in 1992,

189
00:08:27,474 --> 00:08:30,610
uh, and then continuing
with Jason-1 in 2001

190
00:08:30,610 --> 00:08:32,612
and Jason-2 in 2008,

191
00:08:32,612 --> 00:08:34,748
and we're hopeful to
launch Jason-3

192
00:08:34,748 --> 00:08:38,084
sometime in the next six months,
something like that.

193
00:08:38,084 --> 00:08:41,654
Uh, and so, we're
really excited

194
00:08:41,654 --> 00:08:43,757
about our record
of sea level rise

195
00:08:43,757 --> 00:08:47,327
because, uh, it's one of the
most accurate means we have

196
00:08:47,327 --> 00:08:48,395
for charting,

197
00:08:48,395 --> 00:08:51,698
how humans are changing
the overall climate,

198
00:08:51,698 --> 00:08:53,199
on the planet.

199
00:08:53,199 --> 00:08:54,200
>> JOSH WILLIS: Because
if you think about it,

200
00:08:54,200 --> 00:08:56,469
the Earth is two-thirds ocean.

201
00:08:56,469 --> 00:08:57,804
>> TOM WAGNER: Great!
Hey, thank you very much

202
00:08:57,804 --> 00:08:59,873
and I know we're going to have
you back later in the show.

203
00:08:59,873 --> 00:09:01,007
But coming up next,
Michelle,

204
00:09:01,007 --> 00:09:02,776
I think we have a video?

205
00:09:02,776 --> 00:09:03,576
>> MICHELLE: Well, yes. In fact,

206
00:09:03,576 --> 00:09:04,778
we're going to be
speaking to a scientist

207
00:09:04,778 --> 00:09:05,812
that actually
does research

208
00:09:05,812 --> 00:09:07,847
sponsored by the NSF
in Greenland.

209
00:09:07,847 --> 00:09:09,315
So if we can roll
the video about

210
00:09:09,315 --> 00:09:12,152
Mike Bevis and
his work, please!

211
00:09:12,152 --> 00:09:13,620
>> MIKE BEVIS:
Yeah, this is the...

212
00:09:13,620 --> 00:09:17,757
this is the champion, uh,
glacier of Greenland.

213
00:09:17,757 --> 00:09:19,058
This is Jakobshavn,

214
00:09:19,058 --> 00:09:23,129
so this is the one that's
losing the most mass.

215
00:09:23,129 --> 00:09:26,366
It's losing so much mass
you can see it in space,

216
00:09:26,366 --> 00:09:28,435
they can see
gravity change.

217
00:09:28,435 --> 00:09:31,371
The loss of the mass is
causing gravity to change.

218
00:09:32,772 --> 00:09:34,474
Yeah, we've got instruments
all over the place

219
00:09:34,474 --> 00:09:36,443
but this is going to be one
of our most important ones.

220
00:09:36,443 --> 00:09:39,546
There's the antenna,
and it's bolted to the rock.

221
00:09:39,546 --> 00:09:43,116
So this ice is the...
is the weight

222
00:09:43,116 --> 00:09:45,685
holding the elastic
Earth down.

223
00:09:45,685 --> 00:09:49,055
As that weight is released
by the loss of ice,

224
00:09:49,055 --> 00:09:51,891
the ground is rising,
that antenna is rising.

225
00:09:51,891 --> 00:09:53,159
>> UNIDENTIFIED SPEAKER:
And you can measure that?

226
00:09:53,159 --> 00:09:54,694
>> MIKE BEVIS:
We can measure that.

227
00:09:54,694 --> 00:09:57,897
That's recording
data 24 hours a day,

228
00:09:57,897 --> 00:09:59,999
year after year after year.

229

00:09:59,999 --> 00:10:01,935
>> TOM WAGNER: Hey! So one
of the other things too is,

230
00:10:01,935 --> 00:10:05,071
how do we take this kind of
measurement you've made here,

231
00:10:05,071 --> 00:10:06,639
with literally a GPS device

232
00:10:06,639 --> 00:10:09,142
out in the field
banged into the rock?

233
00:10:09,142 --> 00:10:11,344
How do you combine that
with satellite information

234
00:10:11,344 --> 00:10:13,179
to get a big picture?

235
00:10:13,179 --> 00:10:14,280
>> MIKE BEVIS:
All the satellite...

236
00:10:14,280 --> 00:10:16,983
all the techniques have got the
strengths and the weaknesses.

237
00:10:16,983 --> 00:10:18,118
Uh so there is... for example,

238
00:10:18,118 --> 00:10:20,687
GRACE is incredibly precise,

239
00:10:20,687 --> 00:10:23,156
it can measure a
tiny change in mass,

240
00:10:23,156 --> 00:10:25,625
but it's not always
sure what that mass is.

241
00:10:25,625 --> 00:10:27,994
It could be the mass of
the rock is changing

242
00:10:27,994 --> 00:10:30,063
if you've got
post-glacial rebound

243
00:10:30,063 --> 00:10:32,932
or it could be the ice
or some combination.

244
00:10:32,932 --> 00:10:35,068
>> MIKE BEVIS:
So in that case,

245
00:10:35,068 --> 00:10:36,970
uh, you have to
make a correction

246
00:10:36,970 --> 00:10:39,239
for what the vertical
movement of the ground is

247
00:10:39,239 --> 00:10:41,541
so you're not spoofed
by a rock change

248
00:10:41,541 --> 00:10:43,276
rather than an ice change.

249
00:10:43,276 --> 00:10:44,878
It turns out
that correction

250

00:10:44,878 --> 00:10:46,546
is about the same
size as the answer.

251
00:10:46,546 --> 00:10:48,348
So if you get the
correction wrong,

252
00:10:48,348 --> 00:10:51,117
you start to get errors
in you answer.

253
00:10:51,117 --> 00:10:52,585
So GPS can help with that

254
00:10:52,585 --> 00:10:54,988
because this is going to
sense both elastic rebound

255
00:10:54,988 --> 00:10:57,190
and the slower
viscous rebound.

256
00:10:57,190 --> 00:11:00,126
And in general, you want to
combine different instruments

257
00:11:00,126 --> 00:11:03,530
so that each instrument is
compensating with its strengths

258
00:11:03,530 --> 00:11:05,832
for the weaknesses of
the other instruments.

259
00:11:05,832 --> 00:11:06,699
>> MICHELLE:
And this is something

260
00:11:06,699 --> 00:11:08,167

that I think most people
don't think about,

261
00:11:08,167 --> 00:11:10,737
the fact that the Earth,
you know, solid land itself

262
00:11:10,737 --> 00:11:12,305
is actually elastic,

263
00:11:12,305 --> 00:11:14,741
but as the ice melts
it's rebounding.

264
00:11:14,741 --> 00:11:16,042
>> MIKE BEVIS:
Yeah, like for example,

265
00:11:16,042 --> 00:11:19,145
I first realized this,
uh, in a big way

266
00:11:19,145 --> 00:11:21,114
when we were looking
at GPS stations

267
00:11:21,114 --> 00:11:22,882
in the Central Amazon basin.

268
00:11:22,882 --> 00:11:25,485
We noticed that these stations
were going up and down

269
00:11:25,485 --> 00:11:27,954
like 16 millimeters
every year.

270
00:11:27,954 --> 00:11:29,189
And then... and
then we looked at

271
00:11:29,189 --> 00:11:30,590
the height of
the Amazon River

272
00:11:30,590 --> 00:11:32,725
and we saw that as the
river was going up

273
00:11:32,725 --> 00:11:33,960
the ground was
going down,

274
00:11:33,960 --> 00:11:36,296
as the river went down
the ground was going up.

275
00:11:36,296 --> 00:11:38,264
It was just the
weight of the water

276
00:11:38,264 --> 00:11:40,900
deflecting the
surface downwards.

277
00:11:40,900 --> 00:11:41,834
>> TOM WAGNER: You've got...
how many stations

278
00:11:41,834 --> 00:11:43,303
do you have in
around Greenland?

279
00:11:43,303 --> 00:11:44,571
>> MIKE BEVIS:
We have 50 in Greenland.

280
00:11:44,571 --> 00:11:47,907
We have a similar number
in West Antarctica.

281
00:11:47,907 --> 00:11:49,776
>> TOM WAGNER: Wow!
And any fascinating results

282
00:11:49,776 --> 00:11:50,510
from any of those
stations particularly?

283
00:11:50,510 --> 00:11:51,344
>> MIKE BEVIS:
Yeah there's a lot,

284
00:11:51,344 --> 00:11:53,346
I mean, for example,
you see the places

285
00:11:53,346 --> 00:11:54,514
where people already knew

286
00:11:54,514 --> 00:11:55,982
is the
major ice loss

287
00:11:55,982 --> 00:11:58,484
like the Jakobshavn glacier
or Thwaites glacier,

288
00:11:58,484 --> 00:12:01,287
there is where you also see
the ground rising the fastest.

289
00:12:01,287 --> 00:12:04,123
One of the interesting
things is we see that,

290
00:12:04,123 --> 00:12:06,893
almost everywhere
it's accelerating.

291
00:12:06,893 --> 00:12:10,096
So for in Jakobshavn
it was rising about

292
00:12:10,096 --> 00:12:12,599
12 millimeters
a year in 2008.

293
00:12:12,599 --> 00:12:14,601
By the end of 2012,

294
00:12:14,601 --> 00:12:17,370
it was going up like 32,
33 millimeters a year.

295
00:12:17,370 --> 00:12:20,306
>> TOM WAGNER: The ground is
coming up 33 millimeters a year.

296
00:12:20,306 --> 00:12:22,242
>> MIKE BEVIS: Yeah,
more than an inch a year

297
00:12:22,242 --> 00:12:25,044
just because of the release
of the weight of the ice.

298
00:12:25,044 --> 00:12:26,012
>> MICHELLE: Wow!

299
00:12:26,012 --> 00:12:26,879
>> TOM WAGNER:
Hey, now, is it hard...

300
00:12:26,879 --> 00:12:29,115
it must be pretty tough
to put these stations in,

301
00:12:29,115 --> 00:12:30,583

in the Polar Regions.

302
00:12:30,583 --> 00:12:31,384
>> MIKE BEVIS:
It's challenging

303
00:12:31,384 --> 00:12:34,287
because they've got
to run all year, right?

304
00:12:34,287 --> 00:12:37,824
And so, for a large part
of the year, the winter,

305
00:12:37,824 --> 00:12:39,359
there is no sun,

306
00:12:39,359 --> 00:12:43,096
and so, you have to charge
up huge banks of batteries

307
00:12:43,096 --> 00:12:44,464
so you can get
through the night.

308
00:12:44,464 --> 00:12:47,100
So these are very large,
heavy systems.

309
00:12:47,100 --> 00:12:50,103
I think we spent like $2
million on helicopter fees

310
00:12:50,103 --> 00:12:51,971
just to install G-NET.

311
00:12:51,971 --> 00:12:53,773
Uh all this weight goes in

312

00:12:53,773 --> 00:12:55,241
and then... and then, you...

313
00:12:55,241 --> 00:12:58,044
the sun charges those
batteries all summer long

314
00:12:58,044 --> 00:12:59,679
and then you can run
all through the winter

315
00:12:59,679 --> 00:13:01,748
and send the data
out via satellites.

316
00:13:01,748 --> 00:13:03,716
>> TOM WAGNER: God! Amazing!

317
00:13:03,716 --> 00:13:05,785
>> MICHELLE:
Now, the Earth rebounding,

318
00:13:05,785 --> 00:13:08,321
actually sort of bounding up
after the weight gets taken off,

319
00:13:08,321 --> 00:13:09,622
it must go very slowly.

320
00:13:09,622 --> 00:13:11,791
This isn't something that
just happens immediately.

321
00:13:11,791 --> 00:13:13,960
Is there also something
about the history of the ice

322
00:13:13,960 --> 00:13:16,329
and how the ice has changed
that's in your data as well?

323
00:13:16,329 --> 00:13:17,530
>> MIKE BEVIS: Yeah,
there are actually two...

324
00:13:17,530 --> 00:13:19,198
two ways the Earth behaves.

325
00:13:19,198 --> 00:13:20,600
There's an
elastic response,

326
00:13:20,600 --> 00:13:21,901
which is literally
instantaneous.

327
00:13:21,901 --> 00:13:25,405
So as you lose the ice, there's
an instantaneous adjustment.

328
00:13:25,405 --> 00:13:27,407
But then the Earth
also behaves viscously.

329
00:13:27,407 --> 00:13:31,844
It will flow away from a...
a stress like a weight.

330
00:13:31,844 --> 00:13:34,180
And that's... in
most of the world,

331
00:13:34,180 --> 00:13:37,583
that takes 10,000 years,
say, to happen.

332
00:13:37,583 --> 00:13:42,422
So the ground all around
Fennoscandia is rising now,

333
00:13:42,422 --> 00:13:43,990
not because of
what's happening now,

334
00:13:43,990 --> 00:13:47,126
but because what happened
12,000 years ago

335
00:13:47,126 --> 00:13:48,828
when the ice suddenly
disappeared.

336
00:13:48,828 --> 00:13:49,762
>> TOM WAGNER: God, amazing!

337
00:13:49,762 --> 00:13:51,864
Hey, Mike, thank you very,
very much for joining us.

338
00:13:51,864 --> 00:13:53,333
We really appreciate
you coming in.

339
00:13:53,333 --> 00:13:55,301
>> MICHELLE: Now we're going
to take a really close look

340
00:13:55,301 --> 00:13:57,537
at what's going
on inside the ice.

341
00:13:57,537 --> 00:13:58,738
And, we're going to start

342
00:13:58,738 --> 00:14:00,406
by looking at the
very surface of the ice

343
00:14:00,406 --> 00:14:02,308

because that's where a lot
of the melt is happening.

344
00:14:08,981 --> 00:14:10,249
>> NARRATOR: A short
helicopter flight

345
00:14:10,249 --> 00:14:12,251
from the edge of the
Greenland ice sheet

346
00:14:12,251 --> 00:14:15,088
lies a 27-square mile
network of streams

347
00:14:15,088 --> 00:14:18,024
draining the surface of the
ice as it melts in the sun.

348
00:14:20,660 --> 00:14:22,862
This summer, an
interdisciplinary team

349
00:14:22,862 --> 00:14:24,130
of NASA-funded researchers

350
00:14:24,130 --> 00:14:26,532
set up a camp near the
end of that network,

351
00:14:26,532 --> 00:14:29,469
where a large melt pond
emptied into an outlet stream,

352
00:14:29,469 --> 00:14:31,704
which then, a few
hundred meters later,

353
00:14:31,704 --> 00:14:33,473
disappeared under

a snow bridge

354
00:14:33,473 --> 00:14:36,075
and into a stunning
and dangerous moulin,

355
00:14:36,075 --> 00:14:38,377
a hole in the ice
leading far below.

356
00:14:43,583 --> 00:14:45,885
The team had many tools
at their disposal

357
00:14:45,885 --> 00:14:47,920
including drones
to map the area

358
00:14:47,920 --> 00:14:50,523
and provide a comparison
for satellite measurements.

359
00:14:53,426 --> 00:14:56,195
They also employed what was
essentially a boogie board

360
00:14:56,195 --> 00:14:57,964
mounted with a
Doppler instrument

361
00:14:57,964 --> 00:15:00,600
measuring the depth of the river
and the speed of its flow.

362
00:15:01,601 --> 00:15:02,735
Working in shifts,

363
00:15:02,735 --> 00:15:05,304
they conducted 72 straight
hours of measurements

364
00:15:05,304 --> 00:15:08,441
across the stream.

365
00:15:08,441 --> 00:15:11,944
They also made a series of short
helicopter flights upstream

366
00:15:11,944 --> 00:15:14,480
and placed floating sensors
into three tributaries

367
00:15:14,480 --> 00:15:16,716
to measure the
water as it moved.

368
00:15:41,707 --> 00:15:42,842
About an hour later,

369
00:15:42,842 --> 00:15:45,111
the team was thrilled to
see all three drifters

370
00:15:45,111 --> 00:15:47,713
pass by their camp within
a matter of minutes,

371
00:15:47,713 --> 00:15:50,683
presumably relaying a
few last observations

372
00:15:50,683 --> 00:15:52,752
before disappearing
into the moulin.

373
00:16:02,929 --> 00:16:04,363
But measuring
meltwater runoff

374

00:16:04,363 --> 00:16:06,299
was only part of the effort.

375
00:16:06,299 --> 00:16:09,202
Other researchers joined the
team to measure the albedo

376
00:16:09,202 --> 00:16:11,971
or the brightness of the snow
and ice in the region.

377
00:16:13,406 --> 00:16:14,807
This albedo determines

378
00:16:14,807 --> 00:16:17,310
how much of the sun's
energy will be absorbed,

379
00:16:17,310 --> 00:16:19,946
and therefore, how fast
the surface will melt.

380
00:16:22,081 --> 00:16:23,349
From helicopters,

381
00:16:23,349 --> 00:16:25,952
researchers measured
incoming solar radiation

382
00:16:25,952 --> 00:16:28,554
and compared it to the
light reflected by the ice.

383
00:16:29,889 --> 00:16:32,758
They also imaged the ice
using a digital camera,

384
00:16:32,758 --> 00:16:35,394
creating these beautiful
high-resolution mosaics

385
00:16:35,394 --> 00:16:38,297
to better map the region.

386
00:16:38,297 --> 00:16:40,366
After a short but
intense field season,

387
00:16:40,366 --> 00:16:43,002
the researchers packed up
camp and left the ice.

388
00:16:43,002 --> 00:16:44,904
Hopeful that the data
they'd acquired

389
00:16:44,904 --> 00:16:46,606
could help shed
light on the future

390
00:16:46,606 --> 00:16:49,075
of the Greenland ice sheet.

391
00:16:49,075 --> 00:16:51,244
>> MICHELLE: Now, we're going to
go to some of our colleagues,

392
00:16:51,244 --> 00:16:53,412
who are actually out at the
Jet Propulsion Laboratory today

393
00:16:53,412 --> 00:16:54,814
and we're going to
talk to Larry Smith

394
00:16:54,814 --> 00:16:56,816
from the University of
California, Los Angeles

395

00:16:56,816 --> 00:16:59,552
and Vena Chu from the University
of California, Berkeley.

396
00:16:59,552 --> 00:17:01,554
And Tom, maybe you can ask
them about the research.

397
00:17:01,554 --> 00:17:02,421
>> TOM WAGNER:
Hey, Larry and Vena,

398
00:17:02,421 --> 00:17:03,689
thanks for joining us today.

399
00:17:03,689 --> 00:17:04,757
I don't know if
you could see it

400
00:17:04,757 --> 00:17:06,759
but we just showed some video
of you guys out in the field.

401
00:17:06,759 --> 00:17:09,161
Can you tell us a little bit
about your field network

402
00:17:09,161 --> 00:17:10,663
and what it is that
you're measuring?

403
00:17:12,765 --> 00:17:14,300
>> LARRY SMITH:
Sure, absolutely.

404
00:17:14,300 --> 00:17:18,271
Our project focuses on the
hydrology of the surface,

405
00:17:18,271 --> 00:17:21,007

the melting surface of
the Greenland ice sheet,

406
00:17:21,007 --> 00:17:24,877
and this is a surprisingly
little-studied field

407
00:17:24,877 --> 00:17:27,313
in Glaciology for this
part of the world,

408
00:17:27,313 --> 00:17:30,182
but it's an important
one for society

409
00:17:30,182 --> 00:17:31,417
and for sea level rise

410
00:17:31,417 --> 00:17:34,086
because, already,

411
00:17:34,086 --> 00:17:36,622
melting of the surface of
the Greenland ice sheet

412
00:17:36,622 --> 00:17:39,792
is thought to contribute
about half to two-thirds

413
00:17:39,792 --> 00:17:42,094
of the total mass loss
from Greenland

414
00:17:42,094 --> 00:17:45,097
as measured by GRACE,
for example,

415
00:17:45,097 --> 00:17:49,135
with the remainder being
from solid ice calving losses.

416
00:17:49,135 --> 00:17:50,269
But the...

417
00:17:50,269 --> 00:17:53,372
these predictions are
very often based on,

418
00:17:53,372 --> 00:17:54,874
regional climate models

419
00:17:54,874 --> 00:17:57,043
and so what our measurements
are attempting to do

420
00:17:57,043 --> 00:17:58,844
is to provide
some of the first,

421
00:17:58,844 --> 00:18:01,047
real-world
"in situ" measurements

422
00:18:01,047 --> 00:18:02,214
of meltwater production

423
00:18:02,214 --> 00:18:04,383
and runoff on the
surface of the ice sheets

424
00:18:04,383 --> 00:18:08,287
to try to verify and validate
these model predictions

425
00:18:08,287 --> 00:18:10,289
of future sea level rise.

426
00:18:10,289 --> 00:18:11,257
>> TOM WAGNER: Hey, now, Vena,

427
00:18:11,257 --> 00:18:12,825
you're one of the purple
that goes out in the field

428
00:18:12,825 --> 00:18:16,495
and does all the
hard work, right?

429
00:18:16,495 --> 00:18:17,797
>> VENA CHU: Yeah, I've
been going there for

430
00:18:17,797 --> 00:18:19,198
about eight years now.
Yeah, a lot of field time.

431
00:18:19,198 --> 00:18:20,733
>> TOM WAGNER: So tell us
about some of the gear

432
00:18:20,733 --> 00:18:22,234
you take into the field

433
00:18:22,234 --> 00:18:26,305
and what kind of measurements
you actually make?

434
00:18:26,305 --> 00:18:28,741
>> VENA CHU: Well the first goal
is just to get the camp set up

435
00:18:28,741 --> 00:18:31,877
so we have multiple tents
and all our camping gear.

436
00:18:31,877 --> 00:18:34,780
But we also have, uh, we
are measuring discharge,

437
00:18:34,780 --> 00:18:37,917
so the actual amount of water
going through these rivers.

438
00:18:37,917 --> 00:18:40,519
So we have a sort of
like boogie board set up

439
00:18:40,519 --> 00:18:42,521
that we take
across the river.

440
00:18:42,521 --> 00:18:44,390
It's a sort of
a Doppler system

441
00:18:44,390 --> 00:18:46,158
that measures how the
fast the water is flowing

442
00:18:46,158 --> 00:18:47,927
and how deep the
water is flowing.

443
00:18:47,927 --> 00:18:50,196
>> TOM WAGNER: Yeah. So what
I can't get over, though,

444
00:18:50,196 --> 00:18:51,731
it seems like you guys
are also talking about,

445
00:18:51,731 --> 00:18:53,933
it seems like there has
been a big increase recently

446
00:18:53,933 --> 00:18:55,501
in the amount of
melting that's gone on

447
00:18:55,501 --> 00:18:57,303
on the surface of Greenland,

448
00:18:57,303 --> 00:18:59,038
and tell us about that,

449
00:18:59,038 --> 00:19:00,473
tell us kind of
what you're seeing?

450
00:19:00,473 --> 00:19:02,508
I know that some of the
rivers flow pretty fast.

451
00:19:02,508 --> 00:19:03,576
>> LARRY SMITH: Sure.

452
00:19:03,576 --> 00:19:05,745
The satellite
record shows that,

453
00:19:05,745 --> 00:19:09,682
while bumpy with warmer years
and cooler years, in general,

454
00:19:09,682 --> 00:19:15,955
the overall trend has been an
increasing extent, intensity,

455
00:19:15,955 --> 00:19:19,592
and duration of the melt season
on the surface of the ice.

456
00:19:19,592 --> 00:19:22,428
But these course
resolution satellites

457
00:19:22,428 --> 00:19:24,330
are often microwave-based,

458
00:19:24,330 --> 00:19:28,901
don't have the,
the granularity

459
00:19:28,901 --> 00:19:31,804
to see the fine-scale structures
and physical processes

460
00:19:31,804 --> 00:19:35,574
that are routing this
water off the ice sheet.

461
00:19:35,574 --> 00:19:37,276
And this is actually
very important

462
00:19:37,276 --> 00:19:39,345
because one of the
key questions is,

463
00:19:39,345 --> 00:19:42,715
how much of that melt on
the surface of the ice,

464
00:19:42,715 --> 00:19:45,818
particularly as it expands
deeper into the interior,

465
00:19:45,818 --> 00:19:49,488
how much of that melt water is
actually escaping the ice sheet

466
00:19:49,488 --> 00:19:51,357
to contribute to
sea level rise?

467
00:19:51,357 --> 00:19:54,927
At the moment, our assumption
is that all of it does.

468
00:19:54,927 --> 00:19:56,996
But in fact, it's
entirely plausible

469
00:19:56,996 --> 00:19:58,164
that perhaps some of it...

470
00:19:58,164 --> 00:20:01,667
some fraction of it,
is retained by the ice sheet,

471
00:20:01,667 --> 00:20:04,904
refrozen at the surface or
stored within the ice sheet.

472
00:20:04,904 --> 00:20:07,306
And that's why these
field measurements

473
00:20:07,306 --> 00:20:09,608
and also higher-resolution
satellite

474
00:20:09,608 --> 00:20:12,511
and airborne technologies such
as Operation IceBridge,

475
00:20:12,511 --> 00:20:15,247
such as the WorldViews, uh,
series of satellites,

476
00:20:15,247 --> 00:20:18,584
these provide additional
finer-scale resolution

477
00:20:18,584 --> 00:20:20,419
to study these processes

478

00:20:20,419 --> 00:20:22,788
and confirm that indeed
this melt on the surface

479
00:20:22,788 --> 00:20:25,124
is escaping the ice sheet
to the global ocean.

480
00:20:25,124 --> 00:20:26,092
>> TOM WAGNER: Thanks!
Hey, Michelle,

481
00:20:26,092 --> 00:20:28,194
I understand we might
have some video?

482
00:20:28,194 --> 00:20:29,829
>> MICHELLE: That's right. We
actually have some video about

483
00:20:29,829 --> 00:20:32,865
what it's like to work in these
pretty extreme conditions.

484
00:20:32,865 --> 00:20:33,999
>> UNIDENTIFIED SPEAKER:
This is the best time!

485
00:20:33,999 --> 00:20:36,469
How lucky are we to come
up here in Greenland!

486
00:20:36,469 --> 00:20:37,536
>> UNIDENTIFIED SPEAKER:
Something about this place,

487
00:20:37,536 --> 00:20:42,808
uh, gets under our skins
and we keep coming back.

488

00:20:42,808 --> 00:20:43,909
>> UNIDENTIFIED SPEAKER:
You can only reach

489
00:20:43,909 --> 00:20:46,479
this area here with helicopter.

490
00:20:46,479 --> 00:20:48,347
>> UNIDENTIFIED SPEAKER: We're
camping in the ablation zone.

491
00:20:48,347 --> 00:20:50,382
It's very wet
as you can see.

492
00:20:50,382 --> 00:20:52,118
>> UNIDENTIFIED SPEAKER:
Water is running everywhere.

493
00:20:52,118 --> 00:20:54,253
It's flowing into these
chutes and channels

494
00:20:54,253 --> 00:20:58,023
which are getting bigger and
faster with every second.

495
00:20:58,023 --> 00:21:00,559
If someone... goodness help us

496
00:21:00,559 --> 00:21:02,995
were to ever fall
into one of these,

497
00:21:02,995 --> 00:21:05,731
uh, there would be no hope.

498
00:21:05,731 --> 00:21:07,233
>> ÅSA RENNERMALM: So
we are very careful

499
00:21:07,233 --> 00:21:09,101
with our safety procedures.

500
00:21:09,101 --> 00:21:13,439
The most important here is
that we all come back home.

501
00:21:13,439 --> 00:21:17,443
>> GRACE ANDREWS: It is a
difficult environment to work in

502
00:21:17,443 --> 00:21:19,044
Um, it's cold here.

503
00:21:19,044 --> 00:21:22,815
There are problems
with equipment.

504
00:21:22,815 --> 00:21:24,183
When you have problems
with equipment,

505
00:21:24,183 --> 00:21:27,520
it's hard to get replacements.

506
00:21:27,520 --> 00:21:30,623
It takes weeks to get
things shipped up.

507
00:21:30,623 --> 00:21:32,725
The temperatures,
and in my case,

508
00:21:32,725 --> 00:21:34,260
the sediment load of rivers

509
00:21:34,260 --> 00:21:38,597
makes it hard to actually

do the sample collection.

510
00:21:38,597 --> 00:21:42,835
But it's also the
most inspiring

511
00:21:42,835 --> 00:21:46,305
and thrilling
environment to work in.

512
00:21:46,305 --> 00:21:48,574
Every day I go out
in the fields,

513
00:21:48,574 --> 00:21:52,077
I look around at my environment,

514
00:21:52,077 --> 00:21:55,314
the ice, the river,
how dynamic it is,

515
00:21:55,314 --> 00:21:58,551
and it reminds me
why I'm out there

516
00:21:58,551 --> 00:22:02,888
and I absolutely love it.

517
00:22:02,888 --> 00:22:04,456
>> VENA CHU: One of the
hardest things there is

518
00:22:04,456 --> 00:22:05,958
just working in those
environments.

519
00:22:05,958 --> 00:22:08,427
I mean, the fact is that
we're working in an area

520
00:22:08,427 --> 00:22:10,663
that not many people
work uptil, you know,

521
00:22:10,663 --> 00:22:12,865
in the last five, you know,
six years or so.

522
00:22:12,865 --> 00:22:14,934
People don't really
work on the ice sheet

523
00:22:14,934 --> 00:22:16,802
when it's melting
all around you,

524
00:22:16,802 --> 00:22:18,571
just even camping is hard,

525
00:22:18,571 --> 00:22:21,407
and, you know, we're dealing
with limited helicopter hours.

526
00:22:21,407 --> 00:22:24,410
So if you need more equipment
or something breaks

527
00:22:24,410 --> 00:22:26,779
and, one of the big things
that we dealt with was,

528
00:22:26,779 --> 00:22:28,914
you know, how do we
keep batteries warm

529
00:22:28,914 --> 00:22:31,884
and, uh, how do we set up
camps so that, you know,

530

00:22:31,884 --> 00:22:33,385
rivers aren't
flowing around us

531
00:22:33,385 --> 00:22:36,555
and melting out around our tent.

532
00:22:36,555 --> 00:22:38,224
>> TOM WAGNER: Hey, can
you tell us a little bit

533
00:22:38,224 --> 00:22:40,192
about what happens?

534
00:22:40,192 --> 00:22:41,360
Where does the water go?

535
00:22:41,360 --> 00:22:42,461
We understand a lot
of it doesn't, say,

536
00:22:42,461 --> 00:22:43,996
flow directly off
the ice sheet

537
00:22:43,996 --> 00:22:48,267
but it goes into these
big holes in the ice.

538
00:22:48,267 --> 00:22:50,369
>> VENA CHU: In fact, these
sinkholes are called Moulins.

539
00:22:50,369 --> 00:22:54,073
In fact, what we've seen is
that all the rivers on the ice,

540
00:22:54,073 --> 00:22:56,542
the majority of them actually
go into these sinkholes

541
00:22:56,542 --> 00:22:59,078
rather than forming long rivers
toward the end of the ice.

542
00:22:59,078 --> 00:23:02,948
So we particularly set up these
camps right near these moulins

543
00:23:02,948 --> 00:23:04,216
so we can measure how fast

544
00:23:04,216 --> 00:23:06,318
and how much water
is going into them.

545
00:23:06,318 --> 00:23:07,686
And, like you were
saying before,

546
00:23:07,686 --> 00:23:09,822
the significance
of these moulins

547
00:23:09,822 --> 00:23:10,990
and these sinkholes is that

548
00:23:10,990 --> 00:23:13,993
it takes water into the
bottom of the ice sheet,

549
00:23:13,993 --> 00:23:15,894
and that's where it
can really affect

550
00:23:15,894 --> 00:23:17,997
how fast the ice is flowing.

551
00:23:17,997 --> 00:23:19,665

And, the more
that's melting,

552
00:23:19,665 --> 00:23:22,234
the more water can go inside.

553
00:23:22,234 --> 00:23:23,669
We've seen in some of our,

554
00:23:23,669 --> 00:23:25,971
you know, high-resolution
satellite maps

555
00:23:25,971 --> 00:23:29,108
that there are thousands
of these holes,

556
00:23:29,108 --> 00:23:31,510
thousands of these rivers
draining into the ice sheet,

557
00:23:31,510 --> 00:23:33,445
and at higher
elevations than we have

558
00:23:33,445 --> 00:23:35,014
ever really known
about before.

559
00:23:35,014 --> 00:23:38,217
Just with the availability
of better satellite imagery,

560
00:23:38,217 --> 00:23:40,119
higher resolution
data we're able to

561
00:23:40,119 --> 00:23:43,122
actually see just how many
of these rivers are,

562
00:23:43,122 --> 00:23:45,324
you know, bringing water into
the bottom of the ice sheet

563
00:23:45,324 --> 00:23:48,894
where it can affect the ice
dynamics and the ice flow.

564
00:23:48,894 --> 00:23:50,629
>> TOM WAGNER: Joining us
now is Dr. Sophie Nowicki.

565
00:23:50,629 --> 00:23:53,098
We're going to talk a little
bit about the actual work

566
00:23:53,098 --> 00:23:57,136
that we do to understand what's
going on inside the ice sheets.

567
00:23:57,136 --> 00:23:58,871
And first, we're going to
show you some more video

568
00:23:58,871 --> 00:24:01,707
from NASA's
Operation IceBridge.

569
00:24:01,707 --> 00:24:03,742
Hey, so Sophie, tell us what
we're looking at right now?

570
00:24:03,742 --> 00:24:04,977
>> SOPHIE NOWICKI:
It's a very nice image.

571
00:24:04,977 --> 00:24:06,111
Basically, you're seeing

572
00:24:06,111 --> 00:24:08,480
what is white is ice
flowing into the sea,

573
00:24:08,480 --> 00:24:10,749
those low ponds, they
are kind of darker.

574
00:24:10,749 --> 00:24:12,851
And you can see that ice
has very complex features,

575
00:24:12,851 --> 00:24:14,920
so different types of
river of ice...

576
00:24:14,920 --> 00:24:15,988
I mean, river of water.

577
00:24:15,988 --> 00:24:17,323
So those are very
different to

578
00:24:17,323 --> 00:24:18,657
what Larry was
showing you before.

579
00:24:18,657 --> 00:24:19,825
This is really hard ice.

580
00:24:19,825 --> 00:24:20,926
>> TOM WAGNER:
This is actual ice?

581
00:24:20,926 --> 00:24:22,294
This isn't water
going into the ocean?

582
00:24:22,294 --> 00:24:24,763

This is something that's like
an ice cube out of my fridge.

583
00:24:24,763 --> 00:24:26,332
>> SOPHIE NOWICKI: Yes, and
then, you know, ice cube.

584
00:24:26,332 --> 00:24:28,734
So what you can map
now with this...

585
00:24:28,734 --> 00:24:31,170
with our measurement
tools' capabilities,

586
00:24:31,170 --> 00:24:33,038
it's the actual
height of the ice.

587
00:24:33,038 --> 00:24:39,078
And as time goes, you see
this is a height of the surface

588
00:24:39,078 --> 00:24:40,245
-- >> TOM WAGNER:
Okay. So over here,

589
00:24:40,245 --> 00:24:41,914
we've got our vertical axis.

590
00:24:41,914 --> 00:24:44,350
That's meters, that's
height of the ice.

591
00:24:44,350 --> 00:24:46,719
And then what, this is along
the flight line itself?

592
00:24:46,719 --> 00:24:47,853
>> SOPHIE NOWICKI: Exactly.

593
00:24:47,853 --> 00:24:49,521
>> TOM WAGNER: Okay. And this
is the height of the ice

594
00:24:49,521 --> 00:24:51,657
going down and that's
the water out there?

595
00:24:51,657 --> 00:24:52,691
>> SOPHIE NOWICKI: Yes.

596
00:24:52,691 --> 00:24:54,093
And so you can see
there's a big drop.

597
00:24:54,093 --> 00:24:55,594
That's where the
ice meets the ocean.

598
00:24:55,594 --> 00:24:58,097
And this drop, the second,
is going backwards,

599
00:24:58,097 --> 00:24:59,498
at the moment, in time.

600
00:24:59,498 --> 00:25:00,532
>> TOM WAGNER: Whoa!

601
00:25:00,532 --> 00:25:01,800
So that's the ice
front backtracking?

602
00:25:01,800 --> 00:25:03,035
>> MICHELLE: It's
going all the way back.

603
00:25:03,035 --> 00:25:04,770

>> SOPHIE NOWICKI: Yeah. Like a
five-kilometers jump in time.

604
00:25:04,770 --> 00:25:06,238
So it's a very... even
though, you know,

605
00:25:06,238 --> 00:25:07,906
you think about ice
as an ice cube,

606
00:25:07,906 --> 00:25:09,174
it's actually very dynamic.

607
00:25:09,174 --> 00:25:10,909
It kind of moves
back and forth.

608
00:25:10,909 --> 00:25:12,111
>> TOM WAGNER: So -- >>

609
00:25:12,111 --> 00:25:13,112
MICHELLE: Let's talk
a little bit about

610
00:25:13,112 --> 00:25:14,980
how this data was taken because
this is very dramatic, right?

611
00:25:14,980 --> 00:25:16,815
>> MICHELLE: Operation
IceBridge is an aircraft -

612
00:25:16,815 --> 00:25:18,017
>> SOPHIE NOWICKI: Yes.

613
00:25:18,017 --> 00:25:19,818
>> MICHELLE: and the aircraft
actually flies over Greenland

614
00:25:19,818 --> 00:25:22,921
and Antarctica and it
bounces lasers off the ice.

615
00:25:22,921 --> 00:25:24,089
>> SOPHIE NOWICKI: It does.

616
00:25:24,089 --> 00:25:26,225
One of the measurements that
they do is that they measure,

617
00:25:26,225 --> 00:25:27,926
they bounce lasers
off the surface

618
00:25:27,926 --> 00:25:30,429
and it goes back, but they also
kind of have other measurements,

619
00:25:30,429 --> 00:25:31,597
which hopefully we'll see later,

620
00:25:31,597 --> 00:25:32,998
that goes through the ice.

621
00:25:32,998 --> 00:25:35,100
And what's amazing is
that Greenland is so big.

622
00:25:35,100 --> 00:25:38,537
It's about, uh, I mean, a
quarter of the size of the US,

623
00:25:38,537 --> 00:25:42,608
but they flow... NASA has flown
over quite a big portion

624
00:25:42,608 --> 00:25:45,144
of that over the

last few years.

625
00:25:45,144 --> 00:25:47,813
>> ROBERT HALLBERG: So
the research, project

626
00:25:47,813 --> 00:25:51,216
that I was involved in this
past week is looking at

627
00:25:51,216 --> 00:25:54,720
the calving of
tidewater glaciers.

628
00:25:54,720 --> 00:25:57,556
So there are fjords
here in Greenland

629
00:25:57,556 --> 00:26:00,726
where the water comes right up
to the face of the glacier.

630
00:26:00,726 --> 00:26:04,730
The water down below
is warm and salty.

631
00:26:04,730 --> 00:26:07,933
There is meltwater that
comes shooting out

632
00:26:07,933 --> 00:26:10,803
through large gaps of
the base of the -

633
00:26:10,803 --> 00:26:13,505
of the ice sheets
right into the water,

634
00:26:13,505 --> 00:26:16,041
and that creates these

turbulent plumes of water

635
00:26:16,041 --> 00:26:18,744
that draw yet more
warm water in.

636
00:26:18,744 --> 00:26:21,180
And it's this interaction
between the ice

637
00:26:21,180 --> 00:26:23,849
and the ocean that may
help to regulate,

638
00:26:23,849 --> 00:26:26,785
how quickly sea
level will rise.

639
00:26:26,785 --> 00:26:29,588
Our climate models,
because they are global

640
00:26:29,588 --> 00:26:31,356
and have to run
for centuries,

641
00:26:31,356 --> 00:26:32,724
we can only resolve down

642
00:26:32,724 --> 00:26:34,626
to scales of order
a few kilometers.

643
00:26:34,626 --> 00:26:37,296
And yet all the action of
that ice shelf front

644
00:26:37,296 --> 00:26:39,998
is happening on scales of
just a few hundred meters.

645
00:26:39,998 --> 00:26:44,169
It's fun and exciting and
it's stunning to watch.

646
00:26:44,169 --> 00:26:46,105
But one of our challenges
is figuring out

647
00:26:46,105 --> 00:26:49,641
how to incorporate all
that... all that action

648
00:26:49,641 --> 00:26:51,477
that's happening
in small scales

649
00:26:51,477 --> 00:26:55,113
and put it into
global-scale models.

650
00:26:55,113 --> 00:26:56,648
It's absolutely essential.

651
00:26:56,648 --> 00:27:00,185
It's the processes that
are going on in the fjords

652
00:27:00,185 --> 00:27:02,554
and up on the ice
cap that control

653
00:27:02,554 --> 00:27:06,124
how the system is
going to evolve.

654
00:27:06,124 --> 00:27:09,061
We know that sea
level is rising,

655
00:27:09,061 --> 00:27:11,763
we know that the ice
sheets are losing mass,

656
00:27:11,763 --> 00:27:13,699
but we need to understand why,

657
00:27:13,699 --> 00:27:16,201
because it's only that
why that helps us

658
00:27:16,201 --> 00:27:19,404
to project how things will
change in the future.

659
00:27:19,404 --> 00:27:20,806
>> MICHELLE: And it turns
out that that "why"

660
00:27:20,806 --> 00:27:23,275
is actually kind of a
complicated question to answer

661
00:27:23,275 --> 00:27:26,378
because we cannot see directly
inside the ice sheets.

662
00:27:26,378 --> 00:27:27,579
>> TOM WAGNER: Yeah.
And one of the things

663
00:27:27,579 --> 00:27:28,580
that's always impressed me is,

664
00:27:28,580 --> 00:27:30,449
when you look at the modeling
results that came out

665
00:27:30,449 --> 00:27:32,251

of like the IPCC report,

666
00:27:32,251 --> 00:27:35,053
our best projections for
future sea level rise;

667
00:27:35,053 --> 00:27:37,990
Sophie, you were involved with
that, there is a huge spread.

668
00:27:37,990 --> 00:27:39,825
You know, like we talk
about sea level rise

669
00:27:39,825 --> 00:27:41,760
in the next hundred
years being,

670
00:27:41,760 --> 00:27:45,163
"Is it a foot, is it five
feet, could it be more?"

671
00:27:45,163 --> 00:27:47,566
Tell us about how
those models are made?

672
00:27:47,566 --> 00:27:49,935
Like what goes into
them, as a start?

673
00:27:49,935 --> 00:27:51,803
>> SOPHIE NOWICKI: So you
have to think of a model

674
00:27:51,803 --> 00:27:54,239
as a virtual laboratory
that I'm building.

675
00:27:54,239 --> 00:27:55,974
I'm putting all of the things

that I think that matters,

676
00:27:55,974 --> 00:27:57,809
so the snowfall, the bedrock,

677
00:27:57,809 --> 00:27:59,511
how the bedrock reacts.

678
00:27:59,511 --> 00:28:02,080
And then basically, we
let it mix together

679
00:28:02,080 --> 00:28:03,949
and kind of explore
and understand,

680
00:28:03,949 --> 00:28:05,817
the way that if
I poke my system,

681
00:28:05,817 --> 00:28:07,185
what's going to happen.

682
00:28:07,185 --> 00:28:08,620
So if you look at
my projection,

683
00:28:08,620 --> 00:28:09,922
there is a spread

684
00:28:09,922 --> 00:28:11,990
because we try lots
of different scenarios.

685
00:28:11,990 --> 00:28:13,458
Maybe you want to
kind of see,

686
00:28:13,458 --> 00:28:15,360

you know, is the snowfall

687
00:28:15,360 --> 00:28:17,095
going to matter more
in a hundred years,

688
00:28:17,095 --> 00:28:18,597
is it going to
be the ocean?

689
00:28:18,597 --> 00:28:20,632
And as then just showed
in the video before,

690
00:28:20,632 --> 00:28:23,001
I mean, ice-ocean interaction
is quite complex.

691
00:28:23,001 --> 00:28:24,303
>> TOM WAGNER: Right, but
take us back to the basics

692
00:28:24,303 --> 00:28:25,604
just for a second, right?

693
00:28:25,604 --> 00:28:27,673
So you talked about we've
got this numerical model

694
00:28:27,673 --> 00:28:30,242
that describes how the
ice flows into the ocean.

695
00:28:30,242 --> 00:28:31,443
It also takes... you've got

696
00:28:31,443 --> 00:28:33,478
how much snow falls on
the surface of the ice.

697
00:28:33,478 --> 00:28:36,448
But then you mentioned something
like the bedrock underneath,

698
00:28:36,448 --> 00:28:39,384
how does the bedrock
affect an ice sheet model

699
00:28:39,384 --> 00:28:41,086
that's useful
for sea level rise?

700
00:28:41,086 --> 00:28:42,588
>> SOPHIE NOWICKI: So
that's a good question

701
00:28:42,588 --> 00:28:44,256
because before
Operation IceBridge

702
00:28:44,256 --> 00:28:45,891
we had no idea what the
bedrock looked like.

703
00:28:45,891 --> 00:28:47,426
And that's one of
the good...for me,

704
00:28:47,426 --> 00:28:48,827
one of the most beautiful return

705
00:28:48,827 --> 00:28:51,563
about Operation IceBridge
is the shape of the bed.

706
00:28:51,563 --> 00:28:55,367
It matters because it
tells me how big my ice is,

707

00:28:55,367 --> 00:28:57,436
volume of the ice that's
available to flow.

708
00:28:57,436 --> 00:28:58,837
So it's one thing, how
much ice do I have?

709
00:28:58,837 --> 00:29:00,238
>> TOM WAGNER: How
much ice is there? Okay.

710
00:29:00,238 --> 00:29:01,607
>> SOPHIE NOWICKI: But
also, it also matters

711
00:29:01,607 --> 00:29:03,909
because, you know, imagine
you are skiing downhill.

712
00:29:03,909 --> 00:29:06,244
You go quite fast because
it's going downhill.

713
00:29:06,244 --> 00:29:07,479
So the ice is
the same thing.

714
00:29:07,479 --> 00:29:10,949
I'm going to go fly... I
just go down quite fast.

715
00:29:10,949 --> 00:29:13,685
But if I have to fly... if
I have to slide down

716
00:29:13,685 --> 00:29:14,820
if you have skii uphill,

717
00:29:14,820 --> 00:29:16,622

you have to really do
lots of hard work.

718
00:29:16,622 --> 00:29:18,023
It's the same
thing for the ice.

719
00:29:18,023 --> 00:29:20,125
If the bedrock changes and
they have to go uphill,

720
00:29:20,125 --> 00:29:21,326
it's hard work for me.

721
00:29:21,326 --> 00:29:22,427
>> TOM WAGNER: Okay.

722
00:29:22,427 --> 00:29:23,595
>> MICHELLE: And this
must affect the way

723
00:29:23,595 --> 00:29:24,730
that the ice is melting.

724
00:29:24,730 --> 00:29:26,698
I mean, if there is this
terrain underneath Greenland

725
00:29:26,698 --> 00:29:28,033
that we're only
just aware of,

726
00:29:28,033 --> 00:29:30,335
I mean, we discovered
this giant canyon system

727
00:29:30,335 --> 00:29:32,204
from the data from
Operation IceBridge.

728
00:29:32,204 --> 00:29:33,405
>> SOPHIE NOWICKI:
That is correct.

729
00:29:33,405 --> 00:29:34,706
And then also those
canyons that are basically

730
00:29:34,706 --> 00:29:36,108
the size of the
Grand Canyons,

731
00:29:36,108 --> 00:29:39,211
this is also where some of the
water that Larry showed you

732
00:29:39,211 --> 00:29:41,113
going into the surface
is going to be trapped

733
00:29:41,113 --> 00:29:43,982
and locked down and those are
going to affect my ice flow.

734
00:29:43,982 --> 00:29:46,218
>> TOM WAGNER: So - okay,
but one of the other things too

735
00:29:46,218 --> 00:29:47,185
with the bedrock.

736
00:29:47,185 --> 00:29:49,454
So we've been talking
recently about Antarctica

737
00:29:49,454 --> 00:29:51,623
and last year we had those
papers come out where we said,

738

00:29:51,623 --> 00:29:54,226
"Oh my gosh, part of
Antarctica is unstable now

739
00:29:54,226 --> 00:29:56,428
and the sea level is
going to rise rapidly!"

740
00:29:56,428 --> 00:29:57,963
Tell us about what they found

741
00:29:57,963 --> 00:29:59,731
and how that affects models.

742
00:29:59,731 --> 00:30:02,000
>> SOPHIE NOWICKI: So
there basically...

743
00:30:02,000 --> 00:30:04,469
as Operation IceBridge
was flying over,

744
00:30:04,469 --> 00:30:05,437
they managed to kind of

745
00:30:05,437 --> 00:30:07,039
so there is a big
bump in the bed,

746
00:30:07,039 --> 00:30:08,740
and those bumps in
the bed means that

747
00:30:08,740 --> 00:30:12,844
when the ice is changing
due to a warmer ocean,

748
00:30:12,844 --> 00:30:14,946
when the ice is
retreating back

749
00:30:14,946 --> 00:30:17,516
into the interior
of the ice sheet,

750
00:30:17,516 --> 00:30:18,717
if I have a little low bump

751
00:30:18,717 --> 00:30:20,419
then I can basically
anchor myself.

752
00:30:20,419 --> 00:30:21,787
And that's basically
why knowing

753
00:30:21,787 --> 00:30:23,355
the bed is so important because,

754
00:30:23,355 --> 00:30:24,656
"Do I have a place
to anchor myself

755
00:30:24,656 --> 00:30:27,559
as I'm collapsing or do I
don't have a bump in the bed

756
00:30:27,559 --> 00:30:29,194
and therefore
I keep on going?"

757
00:30:29,194 --> 00:30:30,629
>> TOM WAGNER: Uh-huh,
so literally the...

758
00:30:30,629 --> 00:30:33,165
when you retreat past
the anchor point,

759

00:30:33,165 --> 00:30:36,501
the ice pops up and it can
begin almost to float.

760
00:30:36,501 --> 00:30:37,669
>> SOPHIE NOWICKI: It
can begin to float,

761
00:30:37,669 --> 00:30:38,637
and then it's just like,

762
00:30:38,637 --> 00:30:39,705
you know, when you are

763
00:30:39,705 --> 00:30:40,806
-- >> TOM WAGNER: And we're
talking about hundreds,

764
00:30:40,806 --> 00:30:42,974
ice that's how thick,
hundreds of feet?

765
00:30:42,974 --> 00:30:45,010
>> SOPHIE NOWICKI: Yes,
it is hundreds of feet.

766
00:30:45,010 --> 00:30:48,513
So it's quite
impressive, actually,

767
00:30:48,513 --> 00:30:50,382
how dynamic the ice can be.

768
00:30:50,382 --> 00:30:51,717
>> TOM WAGNER: Okay, so
getting back to it, right?

769
00:30:51,717 --> 00:30:53,985
You know, people, I think
one of the problems

770
00:30:53,985 --> 00:30:55,654
that people get
into is they say,

771
00:30:55,654 --> 00:31:00,559
okay, scientists, give
us a projection.

772
00:31:00,559 --> 00:31:02,127
You know somebody wants
to put a power plant

773
00:31:02,127 --> 00:31:03,662
and they want to know
how high sea level

774
00:31:03,662 --> 00:31:05,397
is going to rise in
a hundred years.

775
00:31:05,397 --> 00:31:06,465
Right?

776
00:31:06,465 --> 00:31:07,866
We give them a spread
that goes, you know,

777
00:31:07,866 --> 00:31:08,867
in a hundred years from now,

778
00:31:08,867 --> 00:31:10,235
it's anywhere from
one to five feet,

779
00:31:10,235 --> 00:31:13,905
how does a result like that
affect the projections?

780

00:31:13,905 --> 00:31:16,374
>> SOPHIE NOWICKI:
Yeah. It's hard

781
00:31:16,374 --> 00:31:18,009
because when
you have those...

782
00:31:18,009 --> 00:31:21,947
those projections of
like... of the wide range,

783
00:31:21,947 --> 00:31:23,915
it's because it's
due to the fact

784
00:31:23,915 --> 00:31:25,450
that we're using
different models,

785
00:31:25,450 --> 00:31:27,452
we're using
different data sets.

786
00:31:27,452 --> 00:31:29,387
Sometimes, you know, I
maybe using in my bed

787
00:31:29,387 --> 00:31:31,423
and then somebody else is
using in a different bed,

788
00:31:31,423 --> 00:31:34,392
and so those all come to play
in a way that we couldn't know,

789
00:31:34,392 --> 00:31:38,263
and that's why the spread is
actually at the moment,

790

00:31:38,263 --> 00:31:40,766
you know, is good
because we'll...

791
00:31:40,766 --> 00:31:43,335
we have something to try to
work forward to refining,

792
00:31:43,335 --> 00:31:45,270
and NASA is doing a
huge amount of work

793
00:31:45,270 --> 00:31:46,571
to refining this spread,

794
00:31:46,571 --> 00:31:48,140
because of course I'm
not happy to tell you,

795
00:31:48,140 --> 00:31:51,309
I don't know if it's going
to be one feet or five feet.

796
00:31:51,309 --> 00:31:52,778
I would rather be able to
tell you it's going to be

797
00:31:52,778 --> 00:31:54,813
two and-a-half
foot for planning.

798
00:31:54,813 --> 00:31:56,014
>> SOPHIE NOWICKI:
But at the moment,

799
00:31:56,014 --> 00:31:56,982
this is just the way it is,

800
00:31:56,982 --> 00:31:58,416
the future is

real uncertain

801
00:31:58,416 --> 00:32:00,051
and that's what
we're dealing with.

802
00:32:00,051 --> 00:32:01,553
>> TOM WAGNER: Hey, guys!

803
00:32:01,553 --> 00:32:03,588
>> JOSH WILLIS: Well,
yeah, the...

804
00:32:03,588 --> 00:32:07,559
the oceans are definitely
eating away at the,

805
00:32:07,559 --> 00:32:09,628
Greenland ice
sheet from the edges.

806
00:32:09,628 --> 00:32:12,063
We've known pretty
well, for a long time

807
00:32:12,063 --> 00:32:13,465
that the surface
is melting.

808
00:32:13,465 --> 00:32:15,333
We can see that
melt from space.

809
00:32:15,333 --> 00:32:19,104
And, you know,
Larry and Vena

810
00:32:19,104 --> 00:32:20,472
were out on the ice

811
00:32:20,472 --> 00:32:25,243
watching the rivers of meltwater
dive down into these moulins,

812
00:32:25,243 --> 00:32:27,245
but, more recently,

813
00:32:27,245 --> 00:32:29,748
research has started
to suggest that,

814
00:32:29,748 --> 00:32:32,784
the ice is actually being
eaten away at the edges.

815
00:32:32,784 --> 00:32:36,388
Remember, a lot of these
glaciers which carry the ice

816
00:32:36,388 --> 00:32:39,391
away from the ice sheet
and into the oceans

817
00:32:39,391 --> 00:32:41,760
actually sit right
in the oceans.

818
00:32:41,760 --> 00:32:44,062
They literally have
a toe in the water,

819
00:32:44,062 --> 00:32:46,798
and that makes them
susceptible to warming

820
00:32:46,798 --> 00:32:48,700
and the intrusion
of warm water

821

00:32:48,700 --> 00:32:52,070
from the edges which can melt
away at the glaciers.

822
00:32:52,070 --> 00:32:53,104
>> TOM WAGNER: Tell us
a little bit about

823
00:32:53,104 --> 00:32:54,906
like the continental
shelf around Greenland,

824
00:32:54,906 --> 00:32:56,508
its relationship to the ocean,

825
00:32:56,508 --> 00:32:59,044
and that's relationship
to the ice?

826
00:32:59,044 --> 00:33:00,479
>> JOSH WILLIS: Well,
what's really interesting,

827
00:33:00,479 --> 00:33:02,814
Tom, is that the water
around Greenland

828
00:33:02,814 --> 00:33:04,816
is sort of upside-down.

829
00:33:04,816 --> 00:33:06,785
You have warm water

830
00:33:06,785 --> 00:33:08,954
underneath a layer
of cold water.

831
00:33:08,954 --> 00:33:10,755
Normally, it's the
other way around, right?

832
00:33:10,755 --> 00:33:11,990
Warm water rises.

833
00:33:11,990 --> 00:33:14,960
But the waters around
Greenland are actually,

834
00:33:14,960 --> 00:33:16,461
what we call "inverted,"

835
00:33:16,461 --> 00:33:18,663
meaning that the warm
water is actually at depth

836
00:33:18,663 --> 00:33:21,166
and it's at depth because
it's extra salty.

837
00:33:21,166 --> 00:33:22,901
This water comes
from the Atlantic,

838
00:33:22,901 --> 00:33:24,536
it's a very salty ocean.

839
00:33:24,536 --> 00:33:26,771
The cold water comes
from the arctic

840
00:33:26,771 --> 00:33:29,174
and it's very fresh
so it sits on top.

841
00:33:29,174 --> 00:33:32,444
What this means is that the
warm water has to climb up

842
00:33:32,444 --> 00:33:35,313

the continental shelf and
reach into the fjords

843
00:33:35,313 --> 00:33:37,616
in order to interact
with the glaciers.

844
00:33:37,616 --> 00:33:40,118
So one of the things we're
really interested in is

845
00:33:40,118 --> 00:33:42,621
just how that water
might get there,

846
00:33:42,621 --> 00:33:46,224
what pathways it might take
along the continental shelf.

847
00:33:47,325 --> 00:33:48,460
>> TOM WAGNER: We're
showing some video now

848
00:33:48,460 --> 00:33:49,961
of what it's like
to do that work.

849
00:33:49,961 --> 00:33:51,830
Can you tell us about the
oceanographic measurements

850
00:33:51,830 --> 00:33:56,668
that you actually make and
what goes into making them?

851
00:33:56,668 --> 00:33:58,103
>> JOSH WILLIS:
Yeah, absolutely.

852
00:33:58,103 --> 00:33:59,671

So this is really
exciting because,

853
00:33:59,671 --> 00:34:03,208
this ship has
sailed into a fjord,

854
00:34:03,208 --> 00:34:06,845
which is a long trench
carved by an ancient glacier

855
00:34:06,845 --> 00:34:09,314
and is now filled with
water and they're,

856
00:34:09,314 --> 00:34:10,782
deploying instruments.

857
00:34:10,782 --> 00:34:12,651
Some of them are
called 'moorings'

858
00:34:12,651 --> 00:34:15,554
which sit on the bottom and
collect data for a long time,

859
00:34:15,554 --> 00:34:18,490
and some of them
are CTDs which,

860
00:34:18,490 --> 00:34:20,625
are one-time
measurements of the ocean.

861
00:34:20,625 --> 00:34:22,961
You can see the ship
pushing away icebergs

862
00:34:22,961 --> 00:34:25,263
and folks paddling

through the slush.

863
00:34:25,263 --> 00:34:28,300
It's really hard work,
and it's really difficult.

864
00:34:28,300 --> 00:34:30,168
And, right now, we
actually have a ship,

865
00:34:30,168 --> 00:34:32,237
the 'Cape Race' which
you see right there

866
00:34:32,237 --> 00:34:33,972
at the end of the video,

867
00:34:33,972 --> 00:34:36,041
which is collecting
data about the shape

868
00:34:36,041 --> 00:34:37,943
and depth of these fjords,

869
00:34:37,943 --> 00:34:39,344
because that's really important

870
00:34:39,344 --> 00:34:40,812
for understanding how
that warm water

871
00:34:40,812 --> 00:34:43,982
can climb up onto the shelf
and reach the glaciers.

872
00:34:43,982 --> 00:34:45,650
>> TOM WAGNER: So
tell me a little bit.

873

00:34:45,650 --> 00:34:48,853
You go out and you make a few
point measurements, right?

874
00:34:48,853 --> 00:34:51,122
How do you synthesize
all this stuff together?

875
00:34:51,122 --> 00:34:52,424
You know to get
at those big...

876
00:34:52,424 --> 00:34:54,359
like, what are the big
picture-specific questions

877
00:34:54,359 --> 00:34:55,660
you're trying to answer

878
00:34:55,660 --> 00:34:58,129
and how do you put
all those things together?

879
00:34:58,129 --> 00:35:00,665
>> JOSH WILLIS: Well, most
people would tell you a model,

880
00:35:00,665 --> 00:35:02,100
but I'm going to
say, you just need

881
00:35:02,100 --> 00:35:04,102
a whole lot of those
point measurements.

882
00:35:04,102 --> 00:35:07,138
In fact,
we've only just begun

883
00:35:07,138 --> 00:35:09,441

to study the oceans
around Greenland.

884
00:35:09,441 --> 00:35:10,642
While there have
been a lot of,

885
00:35:10,642 --> 00:35:12,577
moorings placed

886
00:35:12,577 --> 00:35:15,747
and some surveys that have
happened for a long time

887
00:35:15,747 --> 00:35:19,451
in a very few places, the
vast majority of the area

888
00:35:19,451 --> 00:35:21,853
around the island of
Greenland is just unmeasured

889
00:35:21,853 --> 00:35:23,355
in terms of the ocean,

890
00:35:23,355 --> 00:35:25,256
not just how salty

891
00:35:25,256 --> 00:35:27,692
or how fresh or warm
or cold the water might be,

892
00:35:27,692 --> 00:35:29,327
but even how deep it is.

893
00:35:29,327 --> 00:35:31,763
In fact, there are huge
areas around Greenland

894

00:35:31,763 --> 00:35:34,666
where we have no depth
measurements so we don't know

895
00:35:34,666 --> 00:35:37,569
if there are deep
trenches, or sills

896
00:35:37,569 --> 00:35:40,071
that this warm water
might have to climb over.

897
00:35:40,071 --> 00:35:43,241
So we have a whole lot of
observations to make, and,

898
00:35:43,241 --> 00:35:45,944
right now we've
actually begun making

899
00:35:45,944 --> 00:35:48,747
those kinds of observations
with the new mission,

900
00:35:48,747 --> 00:35:51,883
'Oceans Melting
Greenland' or 'OMG'.

901
00:35:51,883 --> 00:35:53,151
>> TOM WAGNER: Yeah, and I
think we're going to share

902
00:35:53,151 --> 00:35:56,488
some video now of how the
aircraft work for OMG.

903
00:35:56,488 --> 00:35:58,023
>> MICHELLE: So describe
this mission here.

904

00:35:58,023 --> 00:36:00,025
>> JOSH WILLIS: Yeah. So
what you're seeing here

905
00:36:00,025 --> 00:36:02,327
is, an aircraft

906
00:36:02,327 --> 00:36:05,163
measurement of the
height of the ice.

907
00:36:05,163 --> 00:36:07,499
And, this is a measurement
that will fly once a year.

908
00:36:07,499 --> 00:36:09,968
We're also measuring
ocean temperatures

909
00:36:09,968 --> 00:36:12,470
using deployable instruments.

910
00:36:12,470 --> 00:36:15,373
So these are being dropped out
of back of the aircraft

911
00:36:15,373 --> 00:36:17,542
They fall through
the water and measure

912
00:36:17,542 --> 00:36:19,044
temperature and salinity,

913
00:36:19,044 --> 00:36:21,579
and then a small float
actually radios that data

914
00:36:21,579 --> 00:36:23,048
back to the airplane.

915
00:36:23,048 --> 00:36:27,285
So those two campaigns
will happen every year

916
00:36:27,285 --> 00:36:28,753
for about five years,

917
00:36:28,753 --> 00:36:31,222
but we also have,
ship-based measurements

918
00:36:31,222 --> 00:36:33,024
of the sea floor depth,

919
00:36:33,024 --> 00:36:36,227
and finally, an airplane
that measures gravity.

920
00:36:36,227 --> 00:36:38,029
And the gravity
measurements are important

921
00:36:38,029 --> 00:36:40,765
because that also
tells you about

922
00:36:40,765 --> 00:36:42,734
the depth of the sea floor.

923
00:36:42,734 --> 00:36:44,269
Whenever you fly
over a trench,

924
00:36:44,269 --> 00:36:46,271
the pull of gravity is
a little bit weaker,

925
00:36:46,271 --> 00:36:49,074
and that's how we can

infer on a lot of places

926
00:36:49,074 --> 00:36:50,508
where we can't drive the ship,

927
00:36:50,508 --> 00:36:52,577
we can infer how
deep the water is.

928
00:36:52,577 --> 00:36:56,081
So all four of these
campaigns are part of the

929
00:36:56,081 --> 00:37:00,418
Oceans Melting Greenland
Mission which started this year.

930
00:37:00,418 --> 00:37:02,253
We have the ship in
the water right now,

931
00:37:02,253 --> 00:37:07,325
and next year we'll be
starting to fly the airplanes.

932
00:37:07,325 --> 00:37:09,027
>> MICHELLE: The really
dramatic interface of the land

933
00:37:09,027 --> 00:37:10,495
and the ocean and ice.

934
00:37:10,495 --> 00:37:11,963
Can you tell us, is there
anything special about

935
00:37:11,963 --> 00:37:14,499
the geography of a fjord
that affects how the ice

936
00:37:14,499 --> 00:37:16,167
and the ocean work together?

937
00:37:16,167 --> 00:37:18,403
>> JOSH WILLIS: Uh the glaciers
dug out these trenches,

938
00:37:18,403 --> 00:37:21,039
uh, on their
path off the land

939
00:37:21,039 --> 00:37:22,507
and towards the ocean

940
00:37:22,507 --> 00:37:26,745
and left behind avenues
for this warm water

941
00:37:26,745 --> 00:37:30,682
to sneak up from the deep and
interact with the glaciers.

942
00:37:30,682 --> 00:37:34,786
So a lot of what scientists
are focusing on today

943
00:37:34,786 --> 00:37:39,791
is this interface where
water meets ice meets land

944
00:37:39,791 --> 00:37:42,794
because that's where
the real action

945
00:37:42,794 --> 00:37:46,064
is in terms of the
ocean-ice interaction.

946
00:37:46,064 --> 00:37:49,100

As we heard about before,
a lot of the meltwater

947
00:37:49,100 --> 00:37:52,937
from the surface actually
digs down through the ice sheet

948
00:37:52,937 --> 00:37:56,141
and it finds its way
to the ocean actually

949
00:37:56,141 --> 00:37:58,209
at the bottom of the ice.

950
00:37:58,209 --> 00:38:00,145
So it often, you know,
in some cases,

951
00:38:00,145 --> 00:38:02,580
it comes out right at
the bottom of the ice,

952
00:38:02,580 --> 00:38:04,482
and then because it's light

953
00:38:04,482 --> 00:38:06,351
and fresh, it surfaces.

954
00:38:06,351 --> 00:38:08,386
That can pull warm water

955
00:38:08,386 --> 00:38:10,188
in towards the
bottom of the glacier

956
00:38:10,188 --> 00:38:11,823
and increase melting,
and that's what

957

00:38:11,823 --> 00:38:14,359
we're really looking
for with OMG.

958
00:38:15,627 --> 00:38:17,162
>> MICHELLE: So here we
see these little arrows

959
00:38:17,162 --> 00:38:18,763
are indicating the
flow of the ice?

960
00:38:18,763 --> 00:38:20,131
>> TOM WAGNER: Right.
So here we are,

961
00:38:20,131 --> 00:38:21,499
the blue is the ocean.

962
00:38:21,499 --> 00:38:22,734
Those blue lines are showing

963
00:38:22,734 --> 00:38:24,502
the direction of
flow of the ice.

964
00:38:24,502 --> 00:38:26,804
And you can see what happens is
it's kind of slow on the sides,

965
00:38:26,804 --> 00:38:28,806
then it gets into this
racetrack in the middle

966
00:38:28,806 --> 00:38:31,643
and it goes out to the ocean.

967
00:38:31,643 --> 00:38:34,045
And what's so fascinating
about this is that

968
00:38:34,045 --> 00:38:35,947
you can see kind of
right at the front.

969
00:38:35,947 --> 00:38:37,682
This stuff is like...
some people call it

970
00:38:37,682 --> 00:38:39,884
like the cork in the
bottle, you know.

971
00:38:39,884 --> 00:38:42,020
And that... these
processes that Josh's team

972
00:38:42,020 --> 00:38:43,721
is studying under OMG,

973
00:38:43,721 --> 00:38:47,225
they are looking at
how the ocean causes

974
00:38:47,225 --> 00:38:49,861
the ice to fracture
more easily,

975
00:38:49,861 --> 00:38:51,930
pull that cork out
of the bottle,

976
00:38:51,930 --> 00:38:54,032
and let the ice
behind it speed up

977
00:38:54,032 --> 00:38:55,967
and really dump in the ocean.

978

00:38:55,967 --> 00:38:57,101
>> MICHELLE: We're really
seeing just how many

979
00:38:57,101 --> 00:38:59,070
complex interactions are
going on here that

980
00:38:59,070 --> 00:39:00,738
as the air warms that
affects the ice,

981
00:39:00,738 --> 00:39:03,074
as the ocean warms that
affects the ice as well.

982
00:39:03,074 --> 00:39:04,509
So this is one of
the reasons we see

983
00:39:04,509 --> 00:39:06,644
such dramatic changes
at the poles.

984
00:39:06,644 --> 00:39:07,679
>> TOM WAGNER: Yeah, and
it's one of the reasons

985
00:39:07,679 --> 00:39:09,247
that NASA gets
involved in this work.

986
00:39:09,247 --> 00:39:11,115
You know you need a lot of
new technology to do this.

987
00:39:11,115 --> 00:39:13,251
A lot of its remote
sensing which means

988

00:39:13,251 --> 00:39:15,086
we make measurements
from far away,

989
00:39:15,086 --> 00:39:16,521
from aircraft or satellites.

990
00:39:16,521 --> 00:39:18,556
But then we kind of take
the view of trying to model it

991
00:39:18,556 --> 00:39:20,725
and pull all those
little pieces together.

992
00:39:20,725 --> 00:39:23,294
This is a Jakobshavn
glacier from Greenland,

993
00:39:23,294 --> 00:39:24,996
one of the most important
outlet glaciers,

994
00:39:24,996 --> 00:39:27,098
it drains quite a
bit of Greenland.

995
00:39:27,098 --> 00:39:31,603
This is where the front of
the glacier was in 1850.

996
00:39:31,603 --> 00:39:34,005
This is where the
glacier was today.

997
00:39:34,005 --> 00:39:35,974
And this is actually,
really recent stuff

998
00:39:35,974 --> 00:39:38,109

from just a few days ago, that
shows you just how much

999
00:39:38,109 --> 00:39:40,612
ice can be lost over the
course of a couple of days.

1000
00:39:42,247 --> 00:39:43,548
>> MICHELLE: So we're
actually seeing ice

1001
00:39:43,548 --> 00:39:44,582
cracking up right there,

1002
00:39:44,582 --> 00:39:45,917
that's the change that
we're looking for?

1003
00:39:45,917 --> 00:39:47,085
>> TOM WAGNER: Right.
>> MICHELLE: Yeah.

1004
00:39:47,085 --> 00:39:48,152
>> TOM WAGNER: But I mean
-- and you are talking,

1005
00:39:48,152 --> 00:39:49,254
again, this is like

1006
00:39:49,254 --> 00:39:51,189
kilometer-scale type
events, you know.

1007
00:39:51,189 --> 00:39:52,390
>> TOM WAGNER: This ice,
actually here is

1008
00:39:52,390 --> 00:39:53,625
some footage of
the thing itself.

1009
00:39:53,625 --> 00:39:55,660
So there are some great
pictures of these,

1010
00:39:55,660 --> 00:39:57,895
but what people have done
is compared the sizes of

1011
00:39:57,895 --> 00:40:00,865
the chunks of ice breaking
off to like buildings.

1012
00:40:00,865 --> 00:40:02,533
And so, some of these
chunks you're looking at,

1013
00:40:02,533 --> 00:40:04,736
they are like as big as
the US Capitol building.

1014
00:40:04,736 --> 00:40:05,837
>> JOSH WILLIS: I
think, you know,

1015
00:40:05,837 --> 00:40:09,607
one of the striking things
about that image of the ice

1016
00:40:09,607 --> 00:40:13,077
breaking off is the timeline
that's associated with it.

1017
00:40:13,077 --> 00:40:15,146
If you look carefully,

1018
00:40:15,146 --> 00:40:19,250
that data goes back
to the late 1800s.

1019
00:40:19,250 --> 00:40:21,252
So this glacier has
been retreating,

1020
00:40:21,252 --> 00:40:25,023
steadily for
the last 150 years.

1021
00:40:25,023 --> 00:40:28,626
And it's
happening, you know,

1022
00:40:28,626 --> 00:40:31,696
on a glacial time-scale,
very rapidly.

1023
00:40:31,696 --> 00:40:34,632
So we're really interested
in trying to study just

1024
00:40:34,632 --> 00:40:37,969
how these things
are proceeding

1025
00:40:37,969 --> 00:40:39,737
and what the role of
the ocean might be

1026
00:40:39,737 --> 00:40:41,673
in helping
to drive them.

1027
00:40:41,673 --> 00:40:44,742
Clearly, if those things are
being eaten away at the edges,

1028
00:40:44,742 --> 00:40:46,477
we need to be able
to quantify that

1029
00:40:46,477 --> 00:40:50,515
if we ever hope to predict
sea level rise into the future.

1030
00:40:50,515 --> 00:40:51,582
>> TOM WAGNER: Hey, Josh!

1031
00:40:51,582 --> 00:40:53,851
Now you are kind of a man
who's a Jack of all trades.

1032
00:40:53,851 --> 00:40:55,687
We're also going to talk
now about Jason-3

1033
00:40:55,687 --> 00:40:57,188
as we kind of
finalize our program

1034
00:40:57,188 --> 00:40:58,189
and we're going to
start talking about

1035
00:40:58,189 --> 00:41:00,625
what are the things that
are coming next for NASA.

1036
00:41:00,625 --> 00:41:02,293
Can you tell us a
little about Jason-3?

1037
00:41:02,293 --> 00:41:03,561
And I understand we
have a picture of it

1038
00:41:03,561 --> 00:41:05,496
to put up that you
might talk to.

1039

00:41:05,496 --> 00:41:07,665
>> JOSH WILLIS: Well,
the Jason missions

1040
00:41:07,665 --> 00:41:09,200
are really in my opinion,

1041
00:41:09,200 --> 00:41:12,003
one of our most
important means

1042
00:41:12,003 --> 00:41:16,708
of measuring the human impact
on the global climate.

1043
00:41:16,708 --> 00:41:20,578
Because these missions
measure the total volume

1044
00:41:20,578 --> 00:41:23,147
of the ocean basically
once every ten days,

1045
00:41:23,147 --> 00:41:24,849
we can really watch how,

1046
00:41:24,849 --> 00:41:28,653
the entire planet is
responding to climate change,

1047
00:41:28,653 --> 00:41:30,688
with kind of
one single number,

1048
00:41:30,688 --> 00:41:33,324
and these satellites
have been providing

1049
00:41:33,324 --> 00:41:36,627
that record since

the early 1990s,

1050
00:41:36,627 --> 00:41:38,963
and we're really looking
forward to Jason-3

1051
00:41:38,963 --> 00:41:41,065
in order to continue
that record.

1052
00:41:41,065 --> 00:41:43,701
A lot of folks ask, "Well,
what's new about Jason-3?"

1053
00:41:43,701 --> 00:41:45,470
And I like to say, "Well,
it's going to measure

1054
00:41:45,470 --> 00:41:48,239
the next five years instead
of the last five years."

1055
00:41:48,239 --> 00:41:51,042
And really, that's a big
deal in climate science.

1056
00:41:51,042 --> 00:41:55,113
A lot of what we need are long
records to be able to compare

1057
00:41:55,113 --> 00:41:57,348
what's going
on to the ice

1058
00:41:57,348 --> 00:42:02,520
and the oceans today with
how they were decades ago.

1059
00:42:02,520 --> 00:42:04,222
>> TOM WAGNER: I think

what people forget is

1060
00:42:04,222 --> 00:42:06,324
some of the big components
of the Earth's system,

1061
00:42:06,324 --> 00:42:08,559
they behave on
decadal timescales.

1062
00:42:08,559 --> 00:42:10,661
Like the Pacific
Decadal Oscillation.

1063
00:42:11,963 --> 00:42:13,564
So tell us a
little about that.

1064
00:42:13,564 --> 00:42:14,832
>> JOSH WILLIS:
Yeah, absolutely.

1065
00:42:14,832 --> 00:42:16,100
One of the things that,

1066
00:42:16,100 --> 00:42:17,735
the satellite altimeters

1067
00:42:17,735 --> 00:42:19,670
do is they
measure sea level,

1068
00:42:19,670 --> 00:42:21,339
not just everywhere
around the globe,

1069
00:42:21,339 --> 00:42:23,541
but in each place
around the globe.

1070
00:42:23,541 --> 00:42:26,711
So you can see clearly
where the Pacific Ocean

1071
00:42:26,711 --> 00:42:30,314
is rising quickly, like
in the West Pacific

1072
00:42:30,314 --> 00:42:32,417
near Indonesia and Australia.

1073
00:42:32,417 --> 00:42:34,919
They've been getting hammered
with rates of sea level rise

1074
00:42:34,919 --> 00:42:38,322
that are three times as
large as the global average.

1075
00:42:38,322 --> 00:42:41,225
So they are getting way
more than their fair share

1076
00:42:41,225 --> 00:42:42,894
of sea level rise.

1077
00:42:42,894 --> 00:42:47,131
We on the West Coast,
here in California,

1078
00:42:47,131 --> 00:42:49,233
have been getting less
than our fair share.

1079
00:42:49,233 --> 00:42:51,569
In fact, in some places
sea levels have actually

1080
00:42:51,569 --> 00:42:55,206

fallen very slightly, and
that sometimes can give us

1081
00:42:55,206 --> 00:42:57,308
a sort of false
sense of security.

1082
00:42:57,308 --> 00:42:59,410
You know, global sea
levels are rising

1083
00:42:59,410 --> 00:43:02,647
and we're going to have
to pay that debt of,

1084
00:43:02,647 --> 00:43:05,817
sea level rise that we
didn't get in the last 20 years

1085
00:43:05,817 --> 00:43:09,020
probably sometime in
the next 20 years.

1086
00:43:09,020 --> 00:43:10,521
>> TOM WAGNER: Josh, thanks a
lot for joining us today!

1087
00:43:10,521 --> 00:43:11,522
We really appreciate it!

1088
00:43:11,522 --> 00:43:12,957
Good luck with
that mission!

1089
00:43:12,957 --> 00:43:14,659
>> MICHELLE: So we've
talked a lot today about

1090
00:43:14,659 --> 00:43:15,960
all kinds of

different scientists

1091
00:43:15,960 --> 00:43:17,261
that are studying ice,

1092
00:43:17,261 --> 00:43:18,863
that are studying
ocean level rise,

1093
00:43:18,863 --> 00:43:21,432
and one of my big questions
is, "What comes next?"

1094
00:43:21,432 --> 00:43:22,867
>> TOM WAGNER: Yeah. So
NASA has actually got

1095
00:43:22,867 --> 00:43:24,168
a bunch of missions coming up

1096
00:43:24,168 --> 00:43:25,503
that's going to
help us with this.

1097
00:43:25,503 --> 00:43:26,871
You know, so the next
thing that's going to happen

1098
00:43:26,871 --> 00:43:28,439
is the Grace
Follow-On Mission

1099
00:43:28,439 --> 00:43:31,142
which we're hoping is going
to provide a higher resolution

1100
00:43:31,142 --> 00:43:33,978
look at this mass loss and
change of the ice sheets.

1101
00:43:33,978 --> 00:43:36,147
Then after that, we have
the ICESat-2 launch.

1102
00:43:36,147 --> 00:43:38,816
An ICESat is this laser
altimeter that goes and --

1103
00:43:38,816 --> 00:43:41,018
literally, it's like a
laser pointer in space,

1104
00:43:41,018 --> 00:43:42,987
tells us very precisely
the height of the ice

1105
00:43:42,987 --> 00:43:44,689
over the entire planet.

1106
00:43:44,689 --> 00:43:46,524
It even also gets used
to measure global forest

1107
00:43:46,524 --> 00:43:48,092
heights and abundance.

1108
00:43:48,092 --> 00:43:49,427
And so then after
that we will have

1109
00:43:49,427 --> 00:43:51,195
what's called the NISAR Mission,

1110
00:43:51,195 --> 00:43:53,030
which is a mission
jointly with India,

1111
00:43:53,030 --> 00:43:55,233
that's a new radar mapper,

that's going to tell us

1112
00:43:55,233 --> 00:43:57,935
a lot about how the
velocity of the ice flow

1113
00:43:57,935 --> 00:43:59,670
to the ocean
has been changing.

1114
00:43:59,670 --> 00:44:01,639
So what we are really
hoping is that we can pull

1115
00:44:01,639 --> 00:44:02,974
all this information
together

1116
00:44:02,974 --> 00:44:04,842
and really narrow down
those error bars

1117
00:44:04,842 --> 00:44:06,377
on the estimates of
sea level rise

1118
00:44:06,377 --> 00:44:08,246
and help society plan.

1119
00:44:08,246 --> 00:44:09,814
>> MICHELLE: And it may
surprise you to know

1120
00:44:09,814 --> 00:44:12,817
that so many NASA resources are
being used to study the ice,

1121
00:44:12,817 --> 00:44:14,118
to study the Earth.

1122
00:44:14,118 --> 00:44:15,319
So when people ask
you the question,

1123
00:44:15,319 --> 00:44:17,288
"Why is NASA studying ice?"

1124
00:44:17,288 --> 00:44:18,389
What's your answer?

1125
00:44:18,389 --> 00:44:19,724
>> TOM WAGNER: You know,
it's a pretty simple answer.

1126
00:44:19,724 --> 00:44:21,058
This is global question.

1127
00:44:21,058 --> 00:44:22,860
You need to measure all the
different parts of the system

1128
00:44:22,860 --> 00:44:25,363
at once and you need different
technologies to do it,

1129
00:44:25,363 --> 00:44:26,564
and new technologies,

1130
00:44:26,564 --> 00:44:28,299
and that's what NASA
excels at, you know.

1131
00:44:28,299 --> 00:44:30,935
And so we build the satellites
and the technologies

1132
00:44:30,935 --> 00:44:33,037
and the aircraft to make
these kinds of measurements

1133
00:44:33,037 --> 00:44:35,172
and we put people in the field
to help pull it together.

1134
00:44:35,172 --> 00:44:37,375
But I should say too, we
also work with our partners.

1135
00:44:37,375 --> 00:44:39,043
You know, the National
Science Foundation,

1136
00:44:39,043 --> 00:44:42,046
the Department of Energy,
NOAA, the USGS,

1137
00:44:42,046 --> 00:44:43,781
they are also all
working on this problem

1138
00:44:43,781 --> 00:44:45,183
and we all work together.

1139
00:44:45,183 --> 00:44:47,451
>> MICHELLE: So NASA is
studying many different aspects

1140
00:44:47,451 --> 00:44:49,287
of how the oceans
are changing,

1141
00:44:49,287 --> 00:44:51,222
and this is something that's
happening right now.

1142
00:44:51,222 --> 00:44:53,124
This is something that's going
to affect all of our lives,

1143
00:44:53,124 --> 00:44:55,560
no matter how close
we actually live to water.

1144
00:44:55,560 --> 00:44:58,596
So on behalf of NASA and
all the scientists of NASA,

1145
00:44:58,596 --> 00:45:00,631
one of the things
I can say is,