
2020
Goddard
Summer
Film
Festival

1
00:01:30,000 --> 00:01:34,400
Operation IceBridge: You may know it from
the beautiful photos that pop up in your

2
00:01:34,400 --> 00:01:37,040
feed,
but did you know that IceBridge is the

3
00:01:37,040 --> 00:01:41,520
largest polar airborne survey of its
kind. IceBridge was designed to study

4
00:01:41,520 --> 00:01:43,920
annual changes in the thickness of sea
ice,

5
00:01:43,920 --> 00:01:48,479
glaciers and ice sheets, as well as
bridge the data gap between the ICESat

6
00:01:48,479 --> 00:01:55,439
and ICESat-2 polar-observing satellites.
Between 2009 and 2019, IceBridge flew

7
00:01:55,439 --> 00:02:00,240
over a thousand scientific missions
gathering data that has redefined our

8
00:02:00,240 --> 00:02:04,159
understanding of the cryosphere.
So let's take a look back at some of the

9
00:02:04,159 --> 00:02:09,840
mission milestones from over the years.
One of the first steps to measure sea

10
00:02:09,840 --> 00:02:13,599
ice thickness is to get a handle on the
amount of snow that accumulates on top

11
00:02:13,599 --> 00:02:17,040
of it.
The IceBridge team pioneered the use of

12
00:02:17,040 --> 00:02:20,800
a snow radar instrument
to gather the first widespread data set

13
00:02:20,800 --> 00:02:26,239
of snow thickness on top of both Arctic
and Antarctic sea ice.

14
00:02:26,959 --> 00:02:30,640
Closer to land, the point at which a
glacier begins to float is called a

15
00:02:30,640 --> 00:02:33,280
grounding line,
and it's a very challenging place to

16
00:02:33,280 --> 00:02:37,760
measure ice thickness.
Using two instruments a radar sounder

17
00:02:37,760 --> 00:02:41,280
and a gravimeter,
the IceBridge team was able to survey

18
00:02:41,280 --> 00:02:44,080
hundreds of these complex transition
zones,

19
00:02:44,080 --> 00:02:49,840
enhancing scientists understanding of
the rapid changes in glacier behavior.

20
00:02:50,000 --> 00:02:54,400
In 2011 NASA scientists discovered a 19-mile long crack

21

00:02:54,400 --> 00:02:58,480
across the Pine Island Glacier, one of
the fastest retreating glaciers in

22
00:02:58,480 --> 00:03:04,319
Antarctica.
The crack measured 260 feet wide and 195

23
00:03:04,319 --> 00:03:08,239
feet deep when it was observed.
Throughout the mission IceBridge was

24
00:03:08,239 --> 00:03:12,640
able to map rifts and ice shelves prior
to major calving events.

25
00:03:12,640 --> 00:03:16,959
And while these events are part of a
natural cycle, IceBridge's observations

26
00:03:16,959 --> 00:03:19,200
helped scientists better record the
changes

27
00:03:19,200 --> 00:03:25,440
in calving frequency and model how they
may be related to a thinning ice shelf.

28
00:03:26,799 --> 00:03:30,879
The motion of the Antarctic ice sheet,
the largest ice sheet in the world,

29
00:03:30,879 --> 00:03:36,000
is heavily influenced by the topography
of the bedrock underneath.

30
00:03:36,000 --> 00:03:41,519
In 2013 the British Antarctic Survey
used over 25 million measurements

31

00:03:41,519 --> 00:03:46,080
collected by IceBridge
and other projects to develop a 3D map

32
00:03:46,080 --> 00:03:49,680
of Antarctica's bedrock topography
called

33
00:03:49,680 --> 00:03:54,159
Bedmap-2. It provided unprecedented
detail of how the continent's bedrock

34
00:03:54,159 --> 00:03:57,599
shaped the flow of the ice sheet.

35
00:03:58,080 --> 00:04:03,519
Data collected by IceBridge enabled many
discoveries in the Arctic as well.

36
00:04:03,519 --> 00:04:07,200
A team from the University of Bristol
used IceBridge's radar data,

37
00:04:07,200 --> 00:04:12,159
along with other data sets, to uncover a
400-mile long canyon buried under nearly

38
00:04:12,159 --> 00:04:17,280
two miles of ice. This hidden canyon is
longer than any other known on Earth

39
00:04:17,280 --> 00:04:21,280
and provides a critical clue to modeling
how melting ice is funneled into the

40
00:04:21,280 --> 00:04:23,100
Arctic Ocean.

41
00:04:24,480 --> 00:04:28,080
Using ice-penetrating radar data

collected by IceBridge,

42
00:04:28,080 --> 00:04:34,180
scientists were able to build the first-ever age map of the layers deep inside the Greenland ice sheet.

43
00:04:36,160 --> 00:04:37,600
For the first time, scientists can

44
00:04:37,600 --> 00:04:40,320
navigate the history of Greenland's ice
layers,

45
00:04:40,320 --> 00:04:44,400
extending previously collected ice cores
to better understand the ice sheets

46
00:04:44,400 --> 00:04:48,380
history and help build models of its future.

47
00:04:49,680 --> 00:04:53,919
An international team of scientists used
decades of NASA data

48
00:04:53,919 --> 00:04:58,160
to uncover a massive impact crater
hiding beneath the Hiawatha Glacier

49
00:04:58,160 --> 00:05:02,560
in northwest Greenland. At roughly a
thousand feet deep

50
00:05:02,560 --> 00:05:06,560
and more than 19 miles wide, it is
potentially one of the youngest large

51
00:05:06,560 --> 00:05:09,020
impact craters on Earth.

52
00:05:11,620 --> 00:05:17,620

Cockpit: "...6. It’s going to happen..5..4..3..2..1

53
00:05:17,900 --> 00:05:21,920
Mark on the overpass 043435 Zulu..."

54
00:05:22,240 --> 00:05:28,080
Ice was bridged on April 8, 2019,
with a direct underflight of the ICESat-2

55
00:05:28,080 --> 00:05:33,919
satellite over Arctic sea ice.
For the first time both ICESat-2 and

56
00:05:33,919 --> 00:05:36,639
IceBridge would be taking the same elevation

57
00:05:36,639 --> 00:05:40,960
measurements over the same
ice. These mirrored measurements were

58
00:05:40,960 --> 00:05:43,759
critical in validating the satellite's
instruments

59
00:05:43,760 --> 00:05:48,680
and continue the legacy of IceBridge
after the mission was completed.

60
00:05:52,400 --> 00:05:57,600
Over the course of its 11-year mission,
IceBridge completed 1,056 scientific

61
00:05:57,600 --> 00:06:00,240
flights and provided a wellspring of data that

62
00:06:00,240 --> 00:06:05,380
fueled the publication of more than 660 papers and counting.

63
00:06:06,200 --> 00:06:09,199

The mission provided new insight into the processes

64
00:06:09,199 --> 00:06:13,440
driving the changes in the cryosphere,
helping scientists better understand

65
00:06:13,440 --> 00:06:17,240
what we can expect in the future.

66
00:06:17,780 --> 00:06:25,360
[music]

67
00:06:26,640 --> 00:06:32,960
The human exploration of space is still
in its infancy. The Apollo missions were

68
00:06:32,960 --> 00:06:36,560
just the first step in our goal to have astronauts working

69
00:06:36,560 --> 00:06:39,640
on the surface of worlds beyond our own.

70
00:06:39,640 --> 00:06:45,800
And as NASA plans its return of humans to the Moon and eventually onto Mars, a team of

71
00:06:45,800 --> 00:06:50,240
scientists have come together to test and build some of the tools our

72
00:06:50,240 --> 00:06:53,740
future explorers may use on these journeys.

73
00:06:53,840 --> 00:06:57,759
Based out of NASA's Goddard Space Flight Center in Greenbelt, Maryland,

74
00:06:57,759 --> 00:07:00,880
this group is called the Goddard
Instrument Field Team,

75

00:07:00,880 --> 00:07:04,260
otherwise known as GIFT.

76
00:07:04,260 --> 00:07:23,760
[music]

77
00:07:24,080 --> 00:07:27,920
The scientists in GIFT collect data on
some of the most unique terrains on

78
00:07:27,920 --> 00:07:31,199
Earth, such as glaciers in Iceland, lava tubes

79
00:07:31,200 --> 00:07:36,440
in Hawaii, maar craters in New Mexico and the desert regions of Chile.

80
00:07:38,080 --> 00:07:39,520
The goal is to conduct field research

81
00:07:39,520 --> 00:07:43,120
and geologic settings that share similarities to locations on

82
00:07:43,120 --> 00:07:47,120
other planets, moons and even asteroids. Scientists call

83
00:07:47,120 --> 00:07:50,720
these sites planetary analogs as they help us learn

84
00:07:50,720 --> 00:07:53,919
how to interpret data from across the solar system

85
00:07:53,920 --> 00:07:58,000
while also getting a better understanding of Earth.

86
00:07:58,480 --> 00:08:01,840
In these environments GIFT researchers
test both commercial

87

00:08:01,840 --> 00:08:04,600
and newly-developed scientific equipment.

88
00:08:04,960 --> 00:08:10,160
These are portable devices that could be used by astronauts or used aboard future rovers

89
00:08:10,160 --> 00:08:12,120
or other types of spacecraft.

90
00:08:12,780 --> 00:08:14,280
These field instruments

91
00:08:14,320 --> 00:08:18,080
are capable of multiple types of
analysis with some providing

92
00:08:18,080 --> 00:08:22,560
instantaneous feedback. The team uses
devices that can observe

93
00:08:22,560 --> 00:08:25,680
and characterize the landscape around a user,

94
00:08:25,680 --> 00:08:28,960
as well as ones that analyze the chemical composition

95
00:08:28,960 --> 00:08:34,000
and physical properties of materials found at and below the surface.

96
00:08:34,000 --> 00:08:38,240
The team also works with instruments
that measure aerosols in the atmosphere,

97
00:08:38,240 --> 00:08:43,519
magnetic fields and solar radiation.
No matter which field campaign they are

98
00:08:43,519 --> 00:08:48,240
on, the scientists in GIFT are selecting

and using their instruments to answer

99
00:08:48,240 --> 00:08:53,040
high-priority science questions. And to more fully capture the essence of

100
00:08:53,040 --> 00:08:56,240
how humans would explore the surface of
the Moon or Mars,

101
00:08:56,240 --> 00:08:59,519
GIFT members also simulate astronaut
EVAs,

102
00:08:59,519 --> 00:09:03,760
or extravehicular activities, at the
planetary analogs they study.

103
00:09:03,760 --> 00:09:09,360
Both former and current astronauts have
accompanied GIFT on these simulations.

104
00:09:09,440 --> 00:09:11,680
Overall, the Goddard Instrument Field Team

105
00:09:11,680 --> 00:09:16,080
provides a unique resource to NASA
and the external science community by

106
00:09:16,080 --> 00:09:18,880
combining the studies of planetary science,

107
00:09:18,880 --> 00:09:24,240
Earth science and hardware technology. All of the tests, experiments and data

108
00:09:24,240 --> 00:09:28,080
collected provide a blueprint for the human exploration

109
00:09:28,080 --> 00:09:30,120
of other worlds.

110
00:09:30,300 --> 00:09:36,520
And that's a great gift for those taking the next giant leap.

111
00:09:36,920 --> 00:10:44,980
[music]

112
00:10:45,920 --> 00:10:51,120
I'm Ernie Wright. I work in the
Scientific Visualization Studio.

113
00:10:51,120 --> 00:10:56,660
My producer David Ladd and I made this
video for the 50th anniversary of Apollo 13.

114
00:10:57,260 --> 00:11:00,560
So Apollo 13 is pretty famously the moon

115
00:11:00,560 --> 00:11:05,040
mission where the oxygen tank explodes,
and the astronauts have to use the lunar

116
00:11:05,040 --> 00:11:06,600
module as a lifeboat.

117
00:11:07,040 --> 00:11:09,380
I'm a big fan of the Tom Hanks movie, but

118
00:11:09,380 --> 00:11:13,440
I wanted to do something that people hadn't seen before, something

119
00:11:13,440 --> 00:11:18,880
that Lunar Reconnaissance Orbiter data
uniquely allows us to do to show what

120
00:11:18,880 --> 00:11:23,720
the crew saw as they flew around the far side of the Moon.

121

00:11:23,920 --> 00:11:25,839
They arrive at the moon about a day

122
00:11:25,839 --> 00:11:29,440
after the explosion. They've been put on a free return

123
00:11:29,440 --> 00:11:33,200
trajectory that will sort of slingshot them around the Moon and send

124
00:11:33,200 --> 00:11:36,880
them home.
I found just enough data in the old

125
00:11:36,880 --> 00:11:40,240
Apollo documents to reconstruct their
flight path.

126
00:11:40,240 --> 00:11:44,959
I put the virtual camera on that path,
and I pointed it at the things they took

127
00:11:44,959 --> 00:11:49,440
pictures of using the same lenses they had on board.

128
00:11:49,440 --> 00:11:53,040
So you see like they saw: Tsiolkovskiy Crater,

129
00:11:53,040 --> 00:11:57,120
and Mare Moscoviense and the Lunar Highlands.

130
00:11:57,120 --> 00:12:01,519
By the way, a lot of the major features
on the far side were named by the Soviet

131
00:12:01,520 --> 00:12:03,600
Union because they were the first to

132
00:12:03,600 --> 00:12:06,960
photograph it in 1959.

133
00:12:08,720 --> 00:12:13,680
I made almost 15 minutes of this stuff.
David cut it together in a way that

134
00:12:13,680 --> 00:12:17,040
found the emotional beats of this part of the journey.

135
00:12:17,040 --> 00:12:20,639
The astronauts were behind the Moon for
almost half an hour,

136
00:12:20,639 --> 00:12:24,000
completely out of contact with the Earth,
and you can just

137
00:12:24,000 --> 00:12:27,760
imagine what it felt like to see the Earth again,

138
00:12:27,760 --> 00:12:32,959
re-establish radio contact and know that they were finally heading home.

139
00:12:32,960 --> 00:12:38,480
It took them almost three more days
before they finally splashed down.

140
00:12:39,120 --> 00:12:42,639
The timing of the explosion was actually
fortunate in a way. If it had happened

141
00:12:42,639 --> 00:12:45,839
during or after the Moon landing,
there wouldn't have been a lunar module

142
00:12:45,839 --> 00:12:49,440
to serve as a lifeboat. And if it was earlier they might not

143
00:12:49,440 --> 00:12:54,000
have had enough power, air and water to make it all the way back.

144
00:12:54,000 --> 00:12:56,880
Thanks for watching.

145
00:13:01,600 --> 00:13:09,540
[music]

146
00:13:09,920 --> 00:13:16,639
America has always been a fertile land.
Grasslands and forests and farms from

147
00:13:16,640 --> 00:13:21,680
sea to shining sea.
The U.S. Department of Agriculture tracks

148
00:13:21,680 --> 00:13:26,900
how many acres and the annual yield for every crop produced.

149
00:13:27,180 --> 00:13:30,320
From the big ones, like corn, wheat,

150
00:13:30,320 --> 00:13:38,160
soy to regional crops, like cotton, rice,
citrus. They track every year using data

151
00:13:38,160 --> 00:13:40,940
from Landsat satellites and others,

152
00:13:41,020 --> 00:13:45,280
combined with data from surveys on the ground.

153
00:13:45,760 --> 00:13:49,440
Landsat satellites see detail at the human scale,

154
00:13:49,440 --> 00:13:52,880
about the size of a baseball diamond, and can image

155
00:13:52,880 --> 00:13:55,400

individual farm fields.

156
00:13:56,340 --> 00:13:59,280
The program started in 1997 with North

157
00:13:59,340 --> 00:14:01,640
Dakota as an experiment.

158
00:14:02,200 --> 00:14:07,279
Other states became interested, and the program grew. In 2008

159
00:14:07,280 --> 00:14:13,360
Landsat data became free to use, and the
USDA could afford to map 48 states.

160
00:14:15,000 --> 00:14:18,920
During the growing season, the data helps estimate crop yields,

161
00:14:18,960 --> 00:14:23,240
which helps farmers and traders set prices for the harvest.

162
00:14:23,280 --> 00:14:29,760
Thanks to Landsat's detailed view,
the USDA tabulates stats, crop by crop,

163
00:14:29,760 --> 00:14:35,279
county by county, and state by state.
At the end of each year, the dataset is

164
00:14:35,280 --> 00:14:38,540
released to the public and it is a beautiful sight.

165
00:14:39,120 --> 00:14:44,700
The patchwork of corn in yellow and soybeans in green in the Midwest.

166
00:14:45,520 --> 00:14:49,420
The diversity of crops in California's Central Valley.

167

00:14:49,560 --> 00:14:54,420
The clusters of citrus in Florida and California and Texas.

168
00:14:54,660 --> 00:14:58,000
We can see changes in farming through the years.

169
00:14:58,200 --> 00:15:00,500
The easiest to see is crop rotation in

170
00:15:00,640 --> 00:15:04,920
the Midwest, cycling between corn and soybeans.

171
00:15:05,600 --> 00:15:09,680
In northern North Dakota, there is a
shift from barley and wheat

172
00:15:09,680 --> 00:15:14,800
to soybeans and canola. And we see an
increase in cotton fields,

173
00:15:14,800 --> 00:15:18,380
shown in red, in Texas and Oklahoma.

174
00:15:19,300 --> 00:15:23,120
Thanks to the free and open access to Landsat data,

175
00:15:23,320 --> 00:15:25,840
the US Department of Agriculture is

176
00:15:25,920 --> 00:15:33,440
providing our farmers with accurate data
and helping maintain our nation's food supply.

177
00:15:36,240 --> 00:15:44,100
[music]

178
00:15:44,600 --> 00:15:49,480
MAVEN is a spacecraft that's orbiting
Mars. It's been there since 2014.

179
00:15:49,620 --> 00:15:54,000
MAVEN, in this case, is an acronym
it stands for Mars Atmosphere and

180
00:15:54,000 --> 00:15:56,959
Volatile Evolution, and this gives a clue as to

181
00:15:56,959 --> 00:16:02,240
what MAVEN's real goal is: it's to study
the top of the atmosphere and how the

182
00:16:02,240 --> 00:16:05,040
gases in the top of the atmosphere might escape

183
00:16:05,040 --> 00:16:07,140
from Mars away to space.

184
00:16:07,140 --> 00:16:09,040
So the atmosphere of Mars must have been a lot

185
00:16:09,080 --> 00:16:11,520
thicker about four billion years ago and today

186
00:16:11,520 --> 00:16:14,800
it's very cold and dry.
And MAVEN is meant to understand the

187
00:16:14,800 --> 00:16:17,600
atmosphere as it is today and how it has
evolved

188
00:16:17,600 --> 00:16:19,420
into this current cold dry state.

189
00:16:19,420 --> 00:16:21,720
One of the things we're trying to understand

190

00:16:21,760 --> 00:16:24,240
with MAVEN is whether a magnetic field for a

191
00:16:24,240 --> 00:16:27,839
planet is important for regulating the climate or allowing the

192
00:16:27,840 --> 00:16:32,560
planet to keep an atmosphere.
Earth has a global dynamo magnetic field.

193
00:16:32,860 --> 00:16:38,440
Mars does not, but Mars has an induced
magnetosphere. It has an induced magnetic field.

194
00:16:38,560 --> 00:16:40,160
The upper atmosphere of Mars is being

195
00:16:40,160 --> 00:16:44,320
ionized by solar radiation,
and so the electrons are being stripped

196
00:16:44,320 --> 00:16:47,199
from the atoms in the atmosphere.
When that happens it turns into what we

197
00:16:47,199 --> 00:16:50,000
call a state of plasma. This plasma in
the upper atmosphere

198
00:16:50,000 --> 00:16:53,120
is very conductive. It leads electric
currents to flow through it.

199
00:16:53,120 --> 00:16:56,320
Electric currents, they shape the
magnetic fields that are around them,

200
00:16:56,320 --> 00:16:59,680
and that's actually how we see them with
MAVEN. We take magnetic field data,

201
00:16:59,680 --> 00:17:03,279
and we map it around the planet. And from
that the currents emerge.

202
00:17:03,279 --> 00:17:06,799
We've known how the currents flow in the
Earth's magnetosphere for decades,

203
00:17:06,799 --> 00:17:10,559
but we don't know how that works around Mars. We don't know how it influences the

204
00:17:10,559 --> 00:17:13,600
interaction with the solar wind
because it determines how energy is

205
00:17:13,600 --> 00:17:17,360
flowing into the atmosphere,
how it's transferred from the solar wind

206
00:17:17,360 --> 00:17:20,959
into the system, and that's what we're
trying to do with MAVEN.

207
00:17:20,959 --> 00:17:24,319
When you just look at the data as it
comes down, you're just seeing a little

208
00:17:24,319 --> 00:17:27,039
squiggly line essentially. You're seeing the magnetic

209
00:17:27,039 --> 00:17:30,240
field strength and its direction vary as
the spacecraft is flying through

210
00:17:30,240 --> 00:17:32,640
different regions. And so what you have to do is you have

211
00:17:32,640 --> 00:17:36,400

to actually map it to the planet
and to this interaction with the solar

212
00:17:36,400 --> 00:17:40,960
wind, and then it starts to emerge that
you have a drape situation where the

213
00:17:40,960 --> 00:17:44,320
magnetic field the solar wind encounters
the planet and it starts to wrap around it.

214
00:17:44,320 --> 00:17:46,240
And the reason it wraps around the

215
00:17:46,240 --> 00:17:49,280
planet is those electric currents that we are seeing.

216
00:17:49,280 --> 00:17:53,360
The magnetic field in the solar wind is
straight lines. You can think of straight

217
00:17:53,360 --> 00:17:56,799
spaghetti noodles, and it's flowing towards the planet and

218
00:17:56,800 --> 00:18:01,240
those spaghetti noodles wrap around this basketball-shaped planet,

219
00:18:01,300 --> 00:18:03,060
and that's indeed what we saw in the data.

220
00:18:03,100 --> 00:18:05,679
The magnetic field lines draping around

221
00:18:05,679 --> 00:18:08,960
Mars as a planet. One thing that wasn't so expected

222
00:18:08,960 --> 00:18:12,320
was the specific configuration of the electric currents

223
00:18:12,320 --> 00:18:16,640
that we derived from the magnetic field
data. If Mars is a ball here it's sort of

224
00:18:16,640 --> 00:18:19,200
this cup shape on the day side that loops

225
00:18:19,200 --> 00:18:22,480
back on itself. Maybe something that looks like this.

226
00:18:22,480 --> 00:18:26,240
What wasn't so intuitive to me was the
directions of those currents

227
00:18:26,240 --> 00:18:30,320
and the fact that it wraps continuously
around to the night

228
00:18:30,320 --> 00:18:33,679
side, and it makes this marvelously complex

229
00:18:33,680 --> 00:18:36,420
current system on the night side as well.

230
00:18:37,160 --> 00:18:38,820
This is the first time that we've been

231
00:18:38,880 --> 00:18:42,160
able to actually map out the currents
so we can see where the energy is being

232
00:18:42,160 --> 00:18:46,720
transferred. We can see what actually
forms the underlying mechanisms creating

233
00:18:46,720 --> 00:18:50,160
these induced magnetospheres that are
not just common here in the solar system,

234
00:18:50,160 --> 00:18:52,240
they're 50 percent of the planets that have them of the

235
00:18:52,240 --> 00:18:56,240
terrestrial planets. And if you want to
understand how the atmosphere of Mars

236
00:18:56,240 --> 00:18:59,440
and Venus, why they're so different from the Earth

237
00:18:59,440 --> 00:19:02,799
and why they're different from each
other, despite both being non-magnetized,

238
00:19:02,799 --> 00:19:06,320
we need to understand their induced
magnetospheres first.

239
00:19:06,320 --> 00:19:10,080
So knowing how these global current
systems are configured

240
00:19:10,080 --> 00:19:14,240
teaches us about how charged particles
near the planet are going to move.

241
00:19:14,240 --> 00:19:18,000
Both charged particles in the solar wind
and charged particles from the

242
00:19:18,000 --> 00:19:22,260
atmosphere itself that are in the process of escaping to space.

243
00:19:22,260 --> 00:19:26,240
So now we can understand better where those particles came from, how they

244
00:19:26,240 --> 00:19:29,679
move near Mars, and where they're going to go next.

245
00:19:29,679 --> 00:19:32,400
That, in turn, teaches us about atmospheric escape from the

246
00:19:32,400 --> 00:19:36,880
planet and the history of the atmosphere
over time. How thick has it been, how much

247
00:19:36,880 --> 00:19:38,600
has been removed.

248
00:19:38,820 --> 00:19:54,140
[music]

249
00:19:54,400 --> 00:19:57,920
It's really satisfying to make someone else's

250
00:19:57,920 --> 00:20:01,480
ideas become a visual reality.

251
00:20:01,480 --> 00:20:12,000
[music]

252
00:20:12,240 --> 00:20:15,520
My name is Bailee. I'm a motion graphics artist

253
00:20:15,520 --> 00:20:20,559
at NASA's Conceptual Image Lab. You know, I start by asking a lot of questions,

254
00:20:20,559 --> 00:20:23,600
and then yeah I still use pencil and paper.

255
00:20:23,600 --> 00:20:29,440
I definitely doodle a lot and take notes during meetings and then and

256
00:20:29,440 --> 00:20:33,679
then make some preliminary sketches.
It's really tempting to start animating

257
00:20:33,679 --> 00:20:36,880
right away but i think sketching those ideas out first

258
00:20:36,880 --> 00:20:40,640
really helps sort of lay the groundwork for the piece.

259
00:20:40,640 --> 00:20:44,080
My name is Jonathan North. The first thing I do is

260
00:20:44,080 --> 00:20:47,280
try and get all the information about a project

261
00:20:47,280 --> 00:20:51,440
that I can. I ask all the questions, like for example,

262
00:20:51,440 --> 00:20:55,520
Dragonfly's going to Titan. I have to know how big Titan is,

263
00:20:55,520 --> 00:21:02,240
the surface, air quality, how it looks.
So once I speak with a scientist and

264
00:21:02,260 --> 00:21:07,520
get all my information, I then go to a rough storyboard.

265
00:21:07,740 --> 00:21:11,360
My name is Adriana Manrique. As we talk
I'll

266
00:21:11,360 --> 00:21:14,880
start sketching, even though if there's like sketches that

267
00:21:14,880 --> 00:21:18,880
take five seconds, less, just to get the ideas down.

268
00:21:18,880 --> 00:21:23,039
They help me break down the big project. They help me troubleshoot

269
00:21:23,040 --> 00:21:28,800
things that otherwise I might not be able to even ask.

270
00:21:31,400 --> 00:21:33,760
My name is Dongjae Krystofer Kim.

271
00:21:33,760 --> 00:21:38,560
Sometimes there are projects that involve both 3D and 2D together, and I

272
00:21:38,560 --> 00:21:42,720
really do enjoy breaking that boundary
I think there was one piece

273
00:21:42,720 --> 00:21:47,840
I did with dark energy for WFIRST, and it
was a highly-stylized piece,

274
00:21:47,840 --> 00:21:54,480
but it also used 3D models. But it was
stylized in a way that it looks 2D, but I

275
00:21:54,480 --> 00:21:59,080
still had the freedom to move the spacecraft around in 3D.

276
00:21:59,200 --> 00:22:03,120
My name is Jacqueline DeMink.
I tend to be like generally like the

277
00:22:03,120 --> 00:22:07,440
more hand-drawn style of 2D animation.

278
00:22:07,440 --> 00:22:13,200
It usually looks more fun and cartoony.
I enjoyed working on the Earth

279
00:22:13,200 --> 00:22:17,600
Expeditions project, the five different missions because I not

280

00:22:17,600 --> 00:22:20,720
only got to do a different style that I never worked

281
00:22:20,720 --> 00:22:24,640
with before, but also I got to learn about five

282
00:22:24,640 --> 00:22:28,660
different missions that NASA was currently doing.

283
00:22:28,720 --> 00:22:32,920
[music]

284
00:22:33,040 --> 00:22:37,600
My background, so i was born in South
America in a country called Guyana.

285
00:22:37,600 --> 00:22:41,840
I was there until like around 12 or so. Coming from Guyana,

286
00:22:41,840 --> 00:22:48,559
it really did influence my art style and artwork. I kind of tend to

287
00:22:48,559 --> 00:22:52,559
try to make everything a little brighter
and a little more fun, add a little

288
00:22:52,560 --> 00:22:56,640
something in there to add a little flair to the work.

289
00:22:56,680 --> 00:22:57,760
Like sometimes I'll get a

290
00:22:57,760 --> 00:23:00,480
lot of ideas I guess just from the natural

291
00:23:00,480 --> 00:23:05,200
world, like the way sunlight hits something. Or maybe

292

00:23:05,200 --> 00:23:08,960
there's like some flowers along a path
that have a really interesting sort of

293
00:23:08,960 --> 00:23:10,100
color palette.

294
00:23:10,100 --> 00:23:12,559
If I can get away with it, I like

295
00:23:12,559 --> 00:23:16,320
to use really bright, punchy colors. Especially

296
00:23:16,320 --> 00:23:21,679
if it's 2D, I like to have swooshing lines, things that are more

297
00:23:21,679 --> 00:23:26,240
sketchy almost because I think it just
gives the work a lot of energy, like a

298
00:23:26,240 --> 00:23:29,220
raw energy that's very appealing.

299
00:23:29,220 --> 00:23:31,780
[music]

300
00:23:31,840 --> 00:23:36,880
One of the biggest things is getting the
believability of the work, you know.

301
00:23:36,880 --> 00:23:41,660
These are digital images that we are creating to make you believe.

302
00:23:41,880 --> 00:23:46,480
It makes science that would otherwise would be dry. It makes it very

303
00:23:46,480 --> 00:23:49,300
interesting. It even makes it very attractive.

304
00:23:49,380 --> 00:23:53,200
I think science illustration just makes you very observant. You know,

305
00:23:53,200 --> 00:23:55,760
aside from all the techniques and stuff that you learn,

306
00:23:55,760 --> 00:24:00,520
it makes you look more closely at the world.

307
00:24:04,280 --> 00:24:10,980
[music]

308
00:24:11,200 --> 00:24:15,040
Have you ever tried to listen to your
favorite radio station, only to find it

309
00:24:15,040 --> 00:24:18,480
garbled or replaced by a different
station? Well if so, you might have been

310
00:24:18,480 --> 00:24:22,480
the victim of something known as a sporadic e-layer.

311
00:24:22,480 --> 00:24:26,400
There are concentrations of electrically
charged gas called plasma in a region of

312
00:24:26,400 --> 00:24:29,440
space known as the ionosphere. They act
kind of like

313
00:24:29,440 --> 00:24:33,440
mirrors in the sky and bounce radio
transmissions over the horizon and

314
00:24:33,440 --> 00:24:36,799
interfere with your radio. Kind of like two people trying to talk over each

315

00:24:36,799 --> 00:24:39,760
other. Even though we've known about
these layers for

316
00:24:39,760 --> 00:24:43,520
over 80 years now, we still don't fully understand them because

317
00:24:43,520 --> 00:24:47,760
they occur at an altitude that is really
difficult to explore. The air there is so

318
00:24:47,760 --> 00:24:51,520
thin that we can't fly an aircraft, but
it's just thick enough that if we were

319
00:24:51,520 --> 00:24:54,559
to try to orbit a satellite it would
burn up in the atmosphere. So we've only

320
00:24:54,559 --> 00:24:58,559
ever been able to explore a handful.
Well, one planet where the atmosphere is

321
00:24:58,559 --> 00:25:02,400
much thinner is the planet
Mars. And one satellite that is currently

322
00:25:02,400 --> 00:25:06,640
exploring Mars is the MAVEN orbiter.
One of the instruments on MAVEN is

323
00:25:06,640 --> 00:25:10,559
called STATIC, it's designed to measure
plasma escaping from the ionosphere,

324
00:25:10,559 --> 00:25:14,960
this upper atmospheric layer of Mars.
And in the data scientists were seeing

325
00:25:14,960 --> 00:25:17,760

that when MAVEN would fly through a
certain region of the atmosphere,

326
00:25:17,760 --> 00:25:22,240
Poof! There was this big density
enhancement of this plasma concentration.

327
00:25:22,240 --> 00:25:26,080
Scientists realized that they discovered
the Martian equivalent of these layers.

328
00:25:26,080 --> 00:25:29,360
It's exciting because now we have a
place that we can go to to directly

329
00:25:29,360 --> 00:25:32,960
explore these layers with a satellite.
MAVEN has encountered more of these

330
00:25:32,960 --> 00:25:36,080
layers at Mars than we've ever been able
to explore here at Earth.

331
00:25:36,080 --> 00:25:39,679
at Earth the layers are temporary and
unpredictable, but at Mars they seem to

332
00:25:39,679 --> 00:25:41,520
be almost permanent and long long-lived at

333
00:25:41,520 --> 00:25:44,960
predictable locations. Also scientists found something that they

334
00:25:44,960 --> 00:25:48,320
didn't even know could exist. MAVEN discovered the opposite of a layer.

335
00:25:48,320 --> 00:25:51,279
They're calling it a rift, and it's where the sky has been pulled

336

00:25:51,279 --> 00:25:55,120
apart. And rather than a concentration of
this plasma, there's a depletion.

337
00:25:55,120 --> 00:25:59,360
Many models said this actually couldn't
happen, but yet they do exist, and we find

338
00:25:59,360 --> 00:26:02,320
them at Mars. This demonstrates how little we

339
00:26:02,320 --> 00:26:05,600
actually know and how much there still is to discover.

340
00:26:05,600 --> 00:26:08,960
These layers are so common they happen
over our heads all the time.

341
00:26:08,960 --> 00:26:12,000
You yourself have probably detected one
of these with your own radio,

342
00:26:12,000 --> 00:26:14,880
even if you weren't aware of this. And
who would have thought that one of the

343
00:26:14,880 --> 00:26:17,679
best ways to explore them would be to send a spacecraft

344
00:26:17,680 --> 00:26:20,740
300 million miles to the red planet?

345
00:26:21,040 --> 00:26:29,260
[music]

346
00:26:29,680 --> 00:26:34,400
This year five new missions are taking
off to investigate our home planet.

347

00:26:34,400 --> 00:26:38,080
From coast to coast, these missions will
take a closer look at everything from

348
00:26:38,080 --> 00:26:43,280
sea level rise to snowstorms. All based right here in the United States.

349
00:26:47,840 --> 00:26:52,240
About 200 miles off the coast of San
Francisco, the Sub-Mesoscale Ocean

350
00:26:52,240 --> 00:26:55,679
Dynamics Experiment, or S-MODE, will use measurements from a

351
00:26:55,679 --> 00:26:59,679
research vessel and three planes: a King Air, a Gulf

352
00:26:59,679 --> 00:27:02,720
Stream a Twin Otter to look at how swirling

353
00:27:02,720 --> 00:27:05,600
ocean eddies affect the movement of heat between the

354
00:27:05,600 --> 00:27:07,260
ocean and the atmosphere.

355
00:27:08,800 --> 00:27:10,900
Autonomous wavegliders and ocean gliders

356
00:27:10,900 --> 00:27:14,799
will dive below the surface of the water
to get a full picture of the ocean and

357
00:27:14,800 --> 00:27:15,820
atmosphere.

358
00:27:18,880 --> 00:27:22,799
Together the mission will collect data
about temperature, salinity and ocean

359
00:27:22,799 --> 00:27:25,360
velocity to get a better understanding of how

360
00:27:25,360 --> 00:27:27,940
small eddies affect the upper ocean.

361
00:27:35,020 --> 00:27:36,780
Traveling inland to the Midwest,

362
00:27:36,780 --> 00:27:40,840
the summer months can bring intense thunderstorms

363
00:27:45,840 --> 00:27:49,520
Strong winds formed by these storms can overshoot the troposphere

364
00:27:49,520 --> 00:27:53,200
and reach higher in Earth's atmosphere, injecting pollutants into the

365
00:27:53,200 --> 00:27:56,240
stratosphere, which can affect the ozone layer.

366
00:27:56,360 --> 00:28:00,320
Using an ER-2 plane flying up to 70 thousand feet

367
00:28:00,320 --> 00:28:04,640
the Dynamics and Chemistry of the Summer Stratosphere, or DCOTSS mission,

368
00:28:04,640 --> 00:28:08,159
will investigate how the pollutants
reach the stratosphere and how their

369
00:28:08,160 --> 00:28:10,380
impact could change in the future.

370
00:28:10,380 --> 00:28:19,200
[music]

371
00:28:19,280 --> 00:28:23,440
Farther south, the Mississippi River Delta is sinking as sea levels continue

372
00:28:23,440 --> 00:28:25,000
to rise globally.

373
00:28:31,600 --> 00:28:34,320
The Delta X mission--no acronyms here--

374
00:28:34,400 --> 00:28:36,640
will combine measurements from two planes,

375
00:28:36,640 --> 00:28:40,559
a King Air and a Gulf Stream, with measurements taken on the ground

376
00:28:40,559 --> 00:28:44,559
and in the water to study how and where
soil is naturally transported and

377
00:28:44,560 --> 00:28:46,700
deposited by water.

378
00:28:46,700 --> 00:28:53,560
[music]

379
00:28:53,680 --> 00:28:56,880
This can help researchers better understand how the coastal regions will

380
00:28:56,880 --> 00:28:59,440
be affected by rising sea levels.

381
00:28:59,440 --> 00:29:14,960
[music]

382
00:29:15,440 --> 00:29:19,360
On the East Coast of the United States, the Aerosol Cloud Meteorology

383

00:29:19,360 --> 00:29:22,000
Interactions over the Western Atlantic Experiment,

384
00:29:22,000 --> 00:29:26,399
or ACTIVATE mission, will look at how
clouds in the marine boundary layer,

385
00:29:26,399 --> 00:29:31,760
roughly the two kilometers above the
ocean, affect the water cycle.

386
00:29:31,760 --> 00:29:34,880
These cloud systems cover large stretches of the ocean and

387
00:29:34,880 --> 00:29:37,690
are not well represented in climate models.

388
00:29:37,690 --> 00:29:39,520
ACTIVATE will use two planes,

389
00:29:39,520 --> 00:29:42,559
a Falcon and a King Air, to take measurements remotely

390
00:29:42,560 --> 00:29:47,300
and in situ, including releasing dropsondes through the clouds.

391
00:29:47,300 --> 00:29:56,320
[music]

392
00:29:56,640 --> 00:30:00,080
Flying the same corridor, the Investigation of Microphysics and

393
00:30:00,080 --> 00:30:03,360
Precipitation for Atlantic Coast
Threatening Snowstorms,

394
00:30:03,360 --> 00:30:07,440
or IMPACTS mission, will use measurements on the ground.

395
00:30:07,440 --> 00:30:13,279
Scientific balloons and two planes,
the ER-2 and the P3, to measure snow

396
00:30:13,279 --> 00:30:16,640
storms at all altitudes.

397
00:30:16,720 --> 00:30:20,080
IMPACTS is looking closely at the intense bands of snow that form inside

398
00:30:20,080 --> 00:30:24,740
clouds to improve forecasting of
snowstorms in the future.

399
00:30:24,740 --> 00:30:36,880
[music]

400
00:30:37,280 --> 00:30:40,640
Stay tuned for more as these five missions take off!

401
00:30:40,960 --> 00:30:48,800
[music]

402
00:30:56,160 --> 00:30:59,360
I think one of the things that's really
special about this visualization is that

403
00:30:59,360 --> 00:31:02,240
it's showing this this new and really complex part of

404
00:31:02,240 --> 00:31:04,980
our model, which is atmospheric chemistry.

405
00:31:05,820 --> 00:31:09,120
One of the issues I think with atmospheric
chemistry is that

406
00:31:09,120 --> 00:31:15,279

it's so complicated, and it changes so rapidly on a short scale.

407
00:31:15,280 --> 00:31:20,580
We're not necessarily able to observe it all the time everywhere.

408
00:31:22,140 --> 00:31:25,200
So that's where models come in. By merging models and satellite

409
00:31:25,200 --> 00:31:27,600
data, we get a much fuller picture of what's

410
00:31:27,600 --> 00:31:31,039
going on throughout the atmosphere.
We can see gases that we couldn't see

411
00:31:31,039 --> 00:31:34,000
with satellites alone. We can see the parts of the atmosphere

412
00:31:34,000 --> 00:31:36,480
column that we really need to know at the nose level

413
00:31:36,480 --> 00:31:39,760
contributions of pollutants that we need
to communicate to

414
00:31:39,760 --> 00:31:42,860
policy makers to protect people's health.

415
00:31:44,080 --> 00:31:50,560
So what we are seeing is a visualization
of the composition of the atmosphere

416
00:31:50,560 --> 00:31:55,039
as it relates to air pollution. There are
hundreds of chemicals that all

417
00:31:55,039 --> 00:31:59,440
contribute to those pollutants, and you can see in

418
00:31:59,440 --> 00:32:03,760
this visualization is really what the computer model does

419
00:32:03,760 --> 00:32:06,720
like underneath there are hundreds of chemicals,

420
00:32:06,720 --> 00:32:10,559
they all react with each other. It's a huge dating pool,

421
00:32:10,560 --> 00:32:14,660
and all of the chemicals date each other all the time.

422
00:32:16,080 --> 00:32:19,440
So even though these chemicals, some of
them are present only at these very

423
00:32:19,440 --> 00:32:22,640
dilute concentrations, they're actually quite important so we

424
00:32:22,640 --> 00:32:25,840
have to really track all of these
different molecules to be able to get at

425
00:32:25,840 --> 00:32:29,279
those pieces that people really need.
The pieces of information that affect

426
00:32:29,280 --> 00:32:30,280
human health.

427
00:32:31,040 --> 00:32:33,080
We rely on computer models to gain

428
00:32:33,100 --> 00:32:38,640
additional insights on where is it formed, where is it destroyed,

429
00:32:38,640 --> 00:32:42,240
what are the mechanisms and how it is

formed? But also how can

430
00:32:42,240 --> 00:32:46,399
can it be mitigated? There's all this
interesting stuff going on all around us

431
00:32:46,399 --> 00:32:50,880
that we're not necessarily aware of, and so this the simulation is really

432
00:32:50,880 --> 00:32:53,679
just trying to illustrate what's going on with those

433
00:32:53,679 --> 00:32:57,440
gases, but by showing so many of them, illustrates how complex their

434
00:32:57,440 --> 00:33:01,200
interactions are and how many things are
going on even if we're not aware of them

435
00:33:01,200 --> 00:33:02,540
all the time.

436
00:33:02,720 --> 00:34:25,720
[music]

437
00:34:25,920 --> 00:34:28,720
Ten years ago we couldn't do anything like this, so this is really a

438
00:34:28,720 --> 00:34:32,480
revolutionary type of approach to be able to combine

439
00:34:32,560 --> 00:34:37,000
the satellite and the model, and the thing that impresses me the most

440
00:34:37,120 --> 00:34:40,079
about visualizations like this is just that we can do it.

441
00:34:40,080 --> 00:34:44,080

Just that with all of this complexity,
all of these kinds of things being

442
00:34:44,080 --> 00:34:47,119
transported in the atmosphere,
that this actually works, and when we

443
00:34:47,120 --> 00:34:50,800
compare it against observations,
it actually looks really, really good in

444
00:34:50,800 --> 00:34:55,600
a lot of places. This is a really exciting new frontier for us.

445
00:35:00,560 --> 00:35:08,160
[music]

446
00:35:08,560 --> 00:35:13,120
There's one thing that stands between us
and the harsh environment of space:

447
00:35:13,120 --> 00:35:16,160
our atmosphere. The part of Earth that sustains

448
00:35:16,160 --> 00:35:21,680
all life. But here in the closest town to the North Pole,

449
00:35:21,680 --> 00:35:27,200
it's slowly leaking away. A team headed there to launch

450
00:35:27,200 --> 00:35:30,240
rockets into the leak, but it's not the lack of atmosphere that

451
00:35:30,240 --> 00:35:33,680
they're concerned about. The leak is a natural process that will

452
00:35:33,680 --> 00:35:37,839
take billions of years.
So we're not going to run out anytime soon.

453
00:35:37,839 --> 00:35:41,119
It's part of the larger story of how a planet's atmosphere

454
00:35:41,119 --> 00:35:47,200
changes over time, a key factor in the search for life on other planets.

455
00:35:47,920 --> 00:35:52,000
We have 35 residents and 60 of our team
together

456
00:35:52,000 --> 00:35:55,040
in a town that is completely isolated. There's a plane twice a week,

457
00:35:55,040 --> 00:35:58,160
and there's a thousand polar bears nearby.

458
00:35:58,160 --> 00:36:02,800
this is Doug Rowland, a NASA scientist who's taken his team to Ny-Alesund

459
00:36:02,800 --> 00:36:07,680
on the island of Svalbard. The island
lies beneath one of two regions near

460
00:36:07,680 --> 00:36:10,720
Earth's poles called the cusps. It's where we can

461
00:36:10,720 --> 00:36:14,079
access space directly and where a hundred tons of atmosphere

462
00:36:14,079 --> 00:36:18,240
escapes into space each day.
This escape gives clues to how long an

463
00:36:18,240 --> 00:36:21,680
atmosphere will last and ultimately whether it stays around

464
00:36:21,680 --> 00:36:23,500

long enough to sustain life.

465
00:36:23,500 --> 00:36:25,560
What we're trying to understand is how did

466
00:36:25,560 --> 00:36:29,040
Earth's atmosphere evolve over time
and how do other planets that might be

467
00:36:29,040 --> 00:36:32,940
like Earth or more dissimilar to Earth
how did their atmospheres evolve?

468
00:36:33,960 --> 00:36:39,040
So Doug joined forces with Joran Moen,
a professor at the University of Oslo

469
00:36:39,040 --> 00:36:42,380
who started the Grand Challenge Initiative - Cusp.

470
00:36:42,500 --> 00:36:47,580
It's an international mission to launch
12 rockets into the Earth's northern cusp.

471
00:36:47,640 --> 00:36:49,680
And Doug, he's the mission leader for the

472
00:36:49,680 --> 00:36:51,800
first two rockets of the campaign

473
00:36:51,880 --> 00:36:56,740
[music]

474
00:36:56,880 --> 00:37:00,000
We don't want to waste our rocket. It'll take us three years to make the rocket

475
00:37:00,000 --> 00:37:02,860
only 15 minutes to use it, and I don't waste my shot here.

476
00:37:03,100 --> 00:37:07,680
He's using a sounding rocket, which is different from the bigger rockets that carry satellites and

477
00:37:07,680 --> 00:37:10,960
humans into space. It's a small suborbital rocket that

478
00:37:10,960 --> 00:37:14,720
flies briefly into space,
collects real-time data for around 15

479
00:37:14,720 --> 00:37:19,600
minutes, then falls back to Earth.
it's affordable, quick to build, and can

480
00:37:19,600 --> 00:37:21,560
launch towards a precise point.

481
00:37:21,720 --> 00:37:23,120
The major advantage is that you can

482
00:37:23,120 --> 00:37:25,760
launch into a target on the sky.

483
00:37:25,920 --> 00:37:27,780
But there's a limited launch window and

484
00:37:27,840 --> 00:37:30,560
only one chance to get the launch right

485
00:37:32,000 --> 00:37:35,440
We have these unguided rockets. They go
where you point them unless the wind is

486
00:37:35,440 --> 00:37:37,920
blowing because the wind literally just
blows them over.

487
00:37:37,980 --> 00:37:41,040

We don't launch when there's high wind.
So to measure the winds, they launch

488
00:37:41,040 --> 00:37:45,839
balloons with GPS trackers.
They're released every 15 to 30 minutes,

489
00:37:45,839 --> 00:37:48,640
and then they're monitored to see how fast the

490
00:37:48,640 --> 00:37:50,940
winds are carrying them.

491
00:37:54,400 --> 00:37:58,240
The ground winds were 12, 13 meters per second,

492
00:37:58,240 --> 00:38:01,540
gusting 17, which is way off

493
00:38:01,940 --> 00:38:03,320
You're filled with trepidation, oh my

494
00:38:03,400 --> 00:38:07,540
gosh this thing that I've built,
is it going to work after all this?

495
00:38:10,960 --> 00:38:14,640
So I think we're going to scrub for
today. I'd like to thank everyone. I think

496
00:38:14,640 --> 00:38:17,300
it was a great performance, thanks a lot.

497
00:38:17,700 --> 00:38:22,000
This means that we are scrubbing this operation from today and try again

498
00:38:22,000 --> 00:38:24,480
tomorrow.

499
00:38:26,240 --> 00:38:31,440
The mission is named Visualizing Ion
Outflow via Neutral Atom Sensing-2,

500
00:38:31,440 --> 00:38:37,340
or VISIONS-2. In short they're looking at how oxygen is getting enough energy to escape.

501
00:38:37,420 --> 00:38:39,760
It's a good test of how atmospheric escape works.

502
00:38:39,820 --> 00:38:43,520
Earth's gravity should hold on to the oxygen, and yet we see this gas

503
00:38:43,520 --> 00:38:47,140
shooting off into space.
We're trying to figure out how that works.

504
00:38:47,180 --> 00:38:50,000
That is a science question that has been

505
00:38:50,000 --> 00:38:52,020
hanging around for four decades.

506
00:38:52,340 --> 00:38:57,040
Fortunately, anyone can see atmospheric escape at the right place and time.

507
00:38:57,040 --> 00:39:01,980
In Svalbard, we have the so-called polar
night. It's dark all 24 hours.

508
00:39:02,000 --> 00:39:04,160
This continual darkness is key

509
00:39:04,160 --> 00:39:08,800
for witnessing this. This is the cuspara, it's a type of northern lights that

510
00:39:08,800 --> 00:39:12,400
appears between 8 am and noon, and you can only see it when

511
00:39:12,400 --> 00:39:16,079
it's dark during the day. It looks
similar to the aurora that occurs at night,

512
00:39:16,079 --> 00:39:18,640
but when these iridescent colors dance

513
00:39:18,640 --> 00:39:22,560
at this hour each day, a hundred tons of oxygen escapes from

514
00:39:22,560 --> 00:39:24,980
Earth's atmosphere into space.

515
00:39:25,180 --> 00:39:29,420
This is our sport now, to chase the aurora.

516
00:39:29,500 --> 00:39:34,700
Working with them is the EISCAT radar and Kjell Henriksen Observatory.

517
00:39:34,760 --> 00:39:37,220
They have additional instruments to find the aurora.

518
00:39:37,300 --> 00:39:42,720
Sometimes it's cloudy, so we use radars to track the cusp. We can

519
00:39:42,720 --> 00:39:46,640
give advice that this is the right type of aurora.

520
00:39:46,640 --> 00:39:50,640
This is the wall of science, a collection
of data from satellites and ground

521
00:39:50,640 --> 00:39:54,400
instruments that helps them predict
where the cusp aurora will be.

522
00:39:54,460 --> 00:39:58,960

So the cusp actually isn't a fixed point in
space. It kind of moves around.

523
00:39:58,960 --> 00:40:02,000
What's controlling the cusp's movement is
the Sun

524
00:40:02,000 --> 00:40:06,800
interacting with Earth. Our planet is
surrounded by a magnetic field that

525
00:40:06,800 --> 00:40:10,640
helps us hold on to our atmosphere,
but at the North and South Poles, the

526
00:40:10,640 --> 00:40:15,440
magnetic field bends inwards, creating a corridor between Earth and space.

527
00:40:15,520 --> 00:40:18,640
When energy is released from the Sun via a

528
00:40:18,640 --> 00:40:22,640
solar flare or coronal mass ejection,
all of that energy in the form of

529
00:40:22,640 --> 00:40:26,540
radiation rides down the magnetic field
lines of the Earth and is transferred

530
00:40:26,540 --> 00:40:29,880
and dumped into the Earth's atmosphere.

531
00:40:29,960 --> 00:40:32,720
Electrons cascade into Earth's atmosphere.

532
00:40:32,780 --> 00:40:34,580
They accelerate and collide with oxygen

533
00:40:34,640 --> 00:40:38,800

particles, giving them energy to release light and sometimes enough

534
00:40:38,800 --> 00:40:43,200
energy to escape. Collectively this forms the cusp aurora

535
00:40:43,200 --> 00:40:45,540
and streams of escaping oxygen.

536
00:40:45,740 --> 00:40:48,720
This cusp is in constant motion.

537
00:40:48,880 --> 00:40:50,960
And we've got a fixed trajectory, we really can't

538
00:40:50,960 --> 00:40:54,900
aim where the cusp is. We have to wait
for the cusp to come across our line of sight.

539
00:40:54,920 --> 00:40:56,400
Can you guys hear Kjellmar? We'd like you

540
00:40:56,400 --> 00:40:59,040
as soon as you see an indication that
the cusp is moving close

541
00:40:59,040 --> 00:41:01,260
to move it, the radar dish if we can.

542
00:41:01,260 --> 00:41:06,260
This is EISCAT, it's been very quiet. Very difficult to launch.

543
00:41:10,720 --> 00:41:13,040
Do you think you'll launch today?

544
00:41:13,920 --> 00:41:16,040
No.

545
00:41:16,100 --> 00:41:19,760

Probably about a 60 percent chance of launching.

546
00:41:22,880 --> 00:41:26,400
When we started seeing this really good
data, this clock started counting down,

547
00:41:26,400 --> 00:41:31,040
and that's when everyone realized this is going to happen. We're going to launch.

548
00:41:31,260 --> 00:41:35,360
We're doing everything we can to get that launch off before the aurora

549
00:41:35,360 --> 00:41:39,040
goes away. It is really, really challenging and

550
00:41:39,040 --> 00:41:44,319
nerve-wracking at that point. You can see the tension just rise

551
00:41:44,320 --> 00:41:46,660
in everybody when that happens.

552
00:41:46,740 --> 00:41:51,359
And so everyone's watching their instruments, getting really excited and then at

553
00:41:51,360 --> 00:41:57,120
T-minus one minute, all of us ran out to go see the launch happen.

554
00:42:07,240 --> 00:42:10,400
And then we immediately turned around
and ran right back in

555
00:42:10,400 --> 00:42:15,180
to look at all the data that was coming
back from the instruments.

556
00:42:15,720 --> 00:42:18,720
You know how much time and effort went into it

557

00:42:18,720 --> 00:42:21,920
because we all worked on it and there's just

558
00:42:21,920 --> 00:42:25,100
nothing that compares to that feeling.

559
00:42:25,400 --> 00:42:27,160
Everybody in every one of those little

560
00:42:27,280 --> 00:42:31,520
places you know really just so happy to contribute to uh

561
00:42:31,520 --> 00:42:36,240
to getting the science.
It's really an incredible experience.

562
00:42:36,560 --> 00:42:40,640
This is a story about what it takes to
launch science instruments into space

563
00:42:40,640 --> 00:42:44,160
but the real adventure will be in the
data they sent back.

564
00:42:44,160 --> 00:42:48,560
Hidden within the numbers will be
answers that reach far beyond Earth,

565
00:42:48,560 --> 00:42:52,079
shedding light on how atmospheres
throughout the universe change,

566
00:42:52,080 --> 00:42:55,640
evolve and perhaps support life.

567
00:42:58,380 --> 00:43:01,740
Hi, I'm Joy. And I'm Miles. And we created

568
00:43:01,760 --> 00:43:06,079

the video about NASA's VISIONS-2 campaign in Svalbard.

569
00:43:06,079 --> 00:43:10,240
It took 3 flights and a bus ride to get
there, and when we finally arrived it was

570
00:43:10,240 --> 00:43:13,440
around noon, but it was still pitch dark outside due

571
00:43:13,440 --> 00:43:17,680
to the 24-hour darkness. We wore headlamps everywhere we went, day

572
00:43:17,680 --> 00:43:21,520
or night. The 24-7 darkness wasn't as jarring as I

573
00:43:21,520 --> 00:43:24,880
thought it would be, but I think that's because we also had a

574
00:43:24,880 --> 00:43:29,920
really hectic schedule. We'd wake up at 2:30 a.m every day.

575
00:43:29,920 --> 00:43:33,040
I'd pack up my filming gear and then at
3 a.m

576
00:43:33,040 --> 00:43:36,079
we'd head over to wherever we're filming that day.

577
00:43:36,079 --> 00:43:39,040
Probably the hardest thing about
covering this mission was that there

578
00:43:39,040 --> 00:43:42,079
were so many different things happening
all at the same time.

579
00:43:42,079 --> 00:43:45,359
We really had to plan ahead to figure
out where we were going to be when

580
00:43:45,360 --> 00:43:49,280
to capture it all. One of the things i
was most worried about was being stuck

581
00:43:49,280 --> 00:43:53,520
in the block house during launch. It's
this building right by the rocket,

582
00:43:53,520 --> 00:43:56,720
and when you're in there, you can't be
outside during the launch,

583
00:43:56,720 --> 00:44:01,359
and you can only access that building by
car with an escort. And you can only

584
00:44:01,360 --> 00:44:07,080
arrive and leave at certain times, but evidently we didn't miss the launch.

585
00:44:07,280 --> 00:44:11,120
And it was pretty much the best experience ever.

586
00:44:15,200 --> 00:44:24,160
[music]

587
00:44:24,560 --> 00:44:28,720
People have been hunting for sun grazing
comets for well over 100 years,

588
00:44:28,720 --> 00:44:32,960
but up to 1979, we only knew of less than a dozen.

589
00:44:32,960 --> 00:44:37,119
As of 2020, we have seen around 4,000 sun grazers.

590
00:44:37,120 --> 00:44:43,260
Why did the number increase? The answer
lies along the route most sun grazers follow.

591
00:44:43,260 --> 00:44:45,280
In the late 1800s Heinrich Kreutz

592
00:44:45,280 --> 00:44:48,480
observed that a few recent comets traveling near the Sun

593
00:44:48,480 --> 00:44:50,720
appeared to follow the same orbit.

594
00:44:50,880 --> 00:44:54,640
On this Kreutz Sungrazer Path, as we've come to call it,

595
00:44:54,640 --> 00:44:59,040
it takes the comet several hundred years
to complete one loop around the Sun.

596
00:44:59,040 --> 00:45:02,480
While there are other orbits of sungrazers, Kreutz comets are the most

597
00:45:02,480 --> 00:45:05,359
common. All of the comets in this orbit came

598
00:45:05,359 --> 00:45:07,760
from a single comet that fell apart near the Sun

599
00:45:07,760 --> 00:45:11,920
thousands of years ago. As the comet
moved closer to the Sun,

600
00:45:11,920 --> 00:45:16,240
the ice binding it together evaporated,
breaking it into smaller pieces that the

601
00:45:16,240 --> 00:45:20,240
Sun's gravity pulled apart. Every time a comet comes around the

602
00:45:20,240 --> 00:45:25,440

Kreutz Path, this can happen again,
resulting in a new generation of comets.

603
00:45:25,440 --> 00:45:28,720
It might sound like this would clutter
the solar system full of comets,

604
00:45:28,720 --> 00:45:33,359
but that's not the case. Most of the new
comets are small enough that they become

605
00:45:33,359 --> 00:45:36,240
completely vaporized as they approach
the Sun.

606
00:45:36,240 --> 00:45:39,839
There are more comets observed in the
last few decades, not because there are

607
00:45:39,839 --> 00:45:42,880
more in the solar system, but because we have better ways to see

608
00:45:42,880 --> 00:45:47,760
them when they are close to the Sun.
Spotting a sun grazer from the ground is

609
00:45:47,760 --> 00:45:51,359
almost impossible because of the blinding sunlight.

610
00:45:51,359 --> 00:45:54,720
Now spacecraft uniquely designed to look
at the Sun

611
00:45:54,720 --> 00:45:59,200
can block the brightest sunlight, making
the job a lot easier.

612
00:45:59,200 --> 00:46:03,599
Since the joint ESA-NASA mission SOHO
launched in 1995,

613
00:46:03,599 --> 00:46:07,680
it has shown us thousands more comets
than any tool before it.

614
00:46:07,680 --> 00:46:12,480
With SOHO we can now see the smaller
fainter comets close to the Sun

615
00:46:12,480 --> 00:46:16,560
just long enough to add them to our list
of sungrazers before they vaporize.

616
00:46:16,560 --> 00:46:20,800
The spacecraft's data is available online so now anyone can discover a

617
00:46:20,800 --> 00:46:24,160
comet. Roughly 95 of these comets have been

618
00:46:24,160 --> 00:46:29,119
found by amateur astronomers. SOHO isn't the only Sun-observing

619
00:46:29,119 --> 00:46:32,800
spacecraft to have surprised us with
beautiful images of comets.

620
00:46:32,800 --> 00:46:36,480
NASA's Solar Dynamics Observatory has
spotted sun grazers too,

621
00:46:36,480 --> 00:46:39,599
though less frequently than SOHO.

622
00:46:39,600 --> 00:46:43,280
Now that we can observe comets better than ever, who knows,

623
00:46:43,280 --> 00:46:46,520
maybe you will spot the next sun grazer.

624
00:46:47,640 --> 00:46:54,040
[music]

625
00:46:55,840 --> 00:46:58,000
In this clip you will see four years

626
00:46:58,080 --> 00:47:02,960
covered in 100 seconds of data interplay
where over half a million of reported

627
00:47:02,960 --> 00:47:07,839
cases of Rift Valley Fever affected humans and livestock. This data

628
00:47:07,839 --> 00:47:10,960
visualization gives you a peek into the scientific

629
00:47:10,960 --> 00:47:16,000
research efforts of Dr. Assaf Anyamba,
who for over 20 years has been tracking

630
00:47:16,000 --> 00:47:20,240
diseases from space by combining hundreds of data sets from

631
00:47:20,240 --> 00:47:24,960
satellites and weather stations with
disease reports and mosquito samples.

632
00:47:24,960 --> 00:47:29,920
This is what big science is all about.
Big data all around from the ground and

633
00:47:29,920 --> 00:47:33,119
from space, and science has proven that there is a

634
00:47:33,119 --> 00:47:36,000
cause and effect pattern between climate events and

635
00:47:36,000 --> 00:47:41,599

infectious disease outbreaks. The climate
patterns of El Nino and La Nina,

636
00:47:41,599 --> 00:47:44,720
as measured in the Pacific Ocean near the Equator,

637
00:47:44,720 --> 00:47:48,480
create weather anomalies whose ripple
effects are felt with a two to three

638
00:47:48,480 --> 00:47:52,720
month delay in distant regions such as southern Africa.

639
00:47:52,720 --> 00:47:57,440
For example, the mild 2009 to 2010 El Nino

640
00:47:57,440 --> 00:48:01,040
caused an above normal increase in rainfall and vegetation,

641
00:48:01,040 --> 00:48:06,800
which in turn triggered a large outbreak
of mosquito-borne Rift Valley Fever.

642
00:48:06,800 --> 00:48:10,319
We created this data visualization with Dr. Assaf Anyamba

643
00:48:10,319 --> 00:48:14,720
to showcase complex data associations
and allow the viewers to track the key

644
00:48:14,720 --> 00:48:20,800
indicators over a period of time.
In a sense, this visualization allows you,

645
00:48:20,800 --> 00:48:28,080
the viewer, to see with Dr. Anyamba's eyes
and be guided to the conclusions by the data.

646
00:48:28,720 --> 00:48:34,280

[music]

647
00:48:38,560 --> 00:48:42,480
We are in a very remote environment. It's
a harsh environment.

648
00:48:42,480 --> 00:48:47,440
You move slower, you're tired, your eyes
hurt because it is so bright out there.

649
00:48:47,440 --> 00:48:50,559
You're cold. You can't remember the last
time you were warm,

650
00:48:50,559 --> 00:48:54,000
and to you know kind of make matters
worse you're digging giant holes in the

651
00:48:54,000 --> 00:48:57,119
snow, so you're working hard the whole time

652
00:48:57,120 --> 00:48:59,820
that all of these elements are just pounding on you.

653
00:48:59,820 --> 00:49:05,720
[music, snowmobile engines]

654
00:49:06,240 --> 00:49:09,520
The SnowEx project is really a multi-year campaign

655
00:49:09,520 --> 00:49:13,599
to test different instruments and
techniques for observing snow

656
00:49:13,599 --> 00:49:16,960
characteristics in different regions and and different

657
00:49:16,960 --> 00:49:19,839
snow types. So we collect measurements on the

658
00:49:19,839 --> 00:49:22,160
ground with different ground-based instruments

659
00:49:22,160 --> 00:49:25,280
and observing techniques. We use that to validate

660
00:49:25,280 --> 00:49:28,559
instruments on aircraft and in the air and

661
00:49:28,559 --> 00:49:33,200
eventually hopefully get some instrument on a satellite.

662
00:49:33,200 --> 00:49:36,240
One of the advantages of Grand Mesa is
its elevation. We're

663
00:49:36,240 --> 00:49:40,319
at over 10,000 feet here, and so as you
can see the snow is not

664
00:49:40,319 --> 00:49:45,920
wet at all. And so we want to start by
really proving the concept in dry snow.

665
00:49:45,920 --> 00:49:49,440
A lot of the remote sensing approaches
are also challenged by complex

666
00:49:49,440 --> 00:49:53,040
topography, so really steep topography and as you can see where

667
00:49:53,040 --> 00:49:56,559
we're standing here we're on the top of
a mesa, which is relatively flat. This is

668
00:49:56,559 --> 00:49:59,280
the largest mesa in the world, and so it's a

669
00:49:59,280 --> 00:50:03,359
pretty unique spot to do this work.
Within the pits we're looking at the

670
00:50:03,359 --> 00:50:06,559
vertical stratigraphy, so the layering of the snowpack

671
00:50:06,559 --> 00:50:11,119
and the different characteristics of
those layers: temperature, density.

672
00:50:11,119 --> 00:50:14,640
I'm operating the snow micropenetrometer,

673
00:50:14,640 --> 00:50:17,760
which is one instrument that they use in the pit crews

674
00:50:17,760 --> 00:50:22,079
to look at the hardness of the snow and
to look at the microstructure.

675
00:50:22,079 --> 00:50:25,520
The microstructure is a very, very important characteristic

676
00:50:25,520 --> 00:50:29,599
for these active-passive microwave retrieval,s so we wanted to get that in a

677
00:50:29,600 --> 00:50:31,200
lot of locations.

678
00:50:33,280 --> 00:50:40,080
I've just done a radar survey in a particular way, and we use this type

679
00:50:40,080 --> 00:50:43,920
of sampling strategy, we were calling it a Hiemstra spiral.

680
00:50:43,920 --> 00:50:48,079
It's a spiral pattern. I'm making a hundred measurements per

681
00:50:48,080 --> 00:50:52,720
second as I drive the snowmobile, and that is a very similar measurement

682
00:50:52,720 --> 00:50:54,280
to what's happening on the aircraft.

683
00:50:58,640 --> 00:51:01,920
SWESARR really stands for Snow Water
Equivalent

684
00:51:01,920 --> 00:51:04,960
Synthetic Aperture Radar and Radiometer, and it's

685
00:51:04,960 --> 00:51:08,079
actually two instruments in one. It has a
active radar

686
00:51:08,079 --> 00:51:12,880
and a passive radiometer. Basically they
both work on the microwave frequencies,

687
00:51:12,880 --> 00:51:16,960
and what they do is to penetrate the snowpack a little bit

688
00:51:16,960 --> 00:51:21,280
and give us the volume scattering information

689
00:51:21,280 --> 00:51:25,040
then which we can relate to how much water is inside the snowpack.

690
00:51:25,040 --> 00:51:28,960
Snow water equivalent is really the the
volume of water that's stored in the

691
00:51:28,960 --> 00:51:32,000
snowpack for hydrologic applications. That's

692

00:51:32,000 --> 00:51:35,760
really the most important characteristic
we want to know, how much is available to

693
00:51:35,760 --> 00:51:39,920
melt and where it's going to go,
evaporate into our groundwater,

694
00:51:39,920 --> 00:51:42,760
reservoirs and how much is available.

695
00:51:43,160 --> 00:51:46,640
Our climate's also changing, and snow is playing a really big role in that.

696
00:51:46,640 --> 00:51:50,000
And it's a big piece of the hydrologic cycle that's quite

697
00:51:50,000 --> 00:51:53,359
uncertain, and it's one of the pieces that we

698
00:51:53,359 --> 00:51:56,880
really see as a very high priority to get more

699
00:51:56,880 --> 00:51:59,360
quantitative, more accurate estimates for.

700
00:51:59,640 --> 00:52:04,880
Snow is a really important part of our planet. Provides water, hydropower,

701
00:52:04,880 --> 00:52:08,960
it's a water source for agriculture and
and water supply.

702
00:52:08,960 --> 00:52:12,079
When we have snow in our mountains it's holding it,

703
00:52:12,079 --> 00:52:16,079
it's kind of like timing the melt in like a slow release

704
00:52:16,079 --> 00:52:19,920
versus just an onset of rain or a flood event.

705
00:52:19,920 --> 00:52:23,359
As we build these records for longer
time series,

706
00:52:23,359 --> 00:52:27,200
we would be able to tell how the snow
accumulation is changing over a given

707
00:52:27,200 --> 00:52:30,079
area and how that might impact the

708
00:52:30,079 --> 00:52:33,520
agriculture in that area or how the people live in that area.

709
00:52:33,520 --> 00:52:37,599
I'm really excited about the potential right now. I think there's a lot of

710
00:52:37,599 --> 00:52:42,000
excitement in the snow community. There's a lot of collaboration I think

711
00:52:42,000 --> 00:52:45,599
we really are at a point where we can push the

712
00:52:45,599 --> 00:52:50,400
science forward and move towards a global snow product

713
00:52:50,400 --> 00:52:53,720
and a satellite mission hopefully.

714
00:52:53,720 --> 00:53:01,840
[music]

715
00:53:02,480 --> 00:53:07,680
This is Bennu, a near-Earth asteroid,
a remnant from the origins of the solar

716
00:53:07,680 --> 00:53:11,839
system and the target of NASA's
OSIRIS-REx mission.

717
00:53:11,839 --> 00:53:16,480
When OSIRIS-REx arrived in December 2018, it brought Bennu into focus,

718
00:53:16,480 --> 00:53:20,480
confirming early radar images that
suggested the asteroid was shaped like a

719
00:53:20,480 --> 00:53:24,079
spinning top. But the close-up images also brought a

720
00:53:24,079 --> 00:53:26,800
big surprise.

721
00:53:26,800 --> 00:53:31,440
Before OSIRIS-REx arrived scientists had
expected Bennu's surface to consist

722
00:53:31,440 --> 00:53:35,359
largely of fine-grained material like a sandy beach.

723
00:53:35,359 --> 00:53:40,000
Sand heats up quickly during the day and
cools off quickly at night.

724
00:53:40,000 --> 00:53:43,440
In contrast, solid objects like rocks and boulders

725
00:53:43,440 --> 00:53:48,559
heat up and cool down more slowly.
Infrared telescope observations had

726
00:53:48,559 --> 00:53:52,640
shown that as Bennu rotates, its surface
rapidly heats and cools,

727
00:53:52,640 --> 00:53:56,000
much like a sandy beach. But OSIRIS-REx was greeted

728
00:53:56,000 --> 00:54:02,079
by a rocky world, littered with boulders
the size of cars, the size of houses,

729
00:54:02,079 --> 00:54:06,720
the size of football fields. This
unexpected roughness confronted the

730
00:54:06,720 --> 00:54:11,440
mission with a major challenge.
The main science goal of OSIRIS-REx is

731
00:54:11,440 --> 00:54:15,680
to briefly touch down on Bennu and grab
a sample of fine-grained material for

732
00:54:15,680 --> 00:54:19,280
return to Earth. To protect the spacecraft the original

733
00:54:19,280 --> 00:54:23,040
plan called for touchdown in a
boulder-free zone with a diameter of at

734
00:54:23,040 --> 00:54:27,520
least 164 feet, but as it turns out, boulder-free sites

735
00:54:27,520 --> 00:54:31,760
of that size don't exist. Following arrival

736
00:54:31,760 --> 00:54:35,839
mission planners began looking at safe
zones that are just a few parking spaces

737
00:54:35,839 --> 00:54:38,319
wide with enough loose material to provide a

738
00:54:38,319 --> 00:54:42,400
sample. In mid 2019 they identified four

739
00:54:42,400 --> 00:54:46,319
candidate sites and named them after
birds that can be found in Egypt:

740
00:54:46,319 --> 00:54:53,200
Osprey, Kingfisher, Nightingale and Sandpiper. Mission planners evaluated

741
00:54:53,200 --> 00:54:56,000
each site based on its safety to the spacecraft,

742
00:54:56,000 --> 00:54:59,839
the ease of getting to the site, the amount of sampleable material that it

743
00:54:59,839 --> 00:55:04,079
contains and the science value of the material itself.

744
00:55:04,079 --> 00:55:07,920
After carefully evaluating these criteria, they chose Nightingale as the

745
00:55:07,920 --> 00:55:13,359
primary sample collection site and Osprey as the backup. Nightingale is

746
00:55:13,359 --> 00:55:17,520
located near Bennu's north pole.
It sits inside a small crater measuring

747
00:55:17,520 --> 00:55:21,520
66 feet in diameter.
Nightingale contains mostly fine-grained

748
00:55:21,520 --> 00:55:24,960
material and has multiple areas for
sample collection

749

00:55:24,960 --> 00:55:29,200
It is also the darkest of the candid sites and has high color variation,

750
00:55:29,200 --> 00:55:35,040
suggesting a diverse mineralogy. Osprey
is also located within a 66-foot wide

751
00:55:35,040 --> 00:55:38,079
crater, just north of Bennu's equatorial bulge

752
00:55:38,079 --> 00:55:40,559
and may contain rock types from both the northern

753
00:55:40,559 --> 00:55:45,359
and southern hemispheres. Osprey has the
strongest signal for carbon-rich

754
00:55:45,359 --> 00:55:48,319
materials of all four sites and contains a dark

755
00:55:48,319 --> 00:55:52,960
patch at its center that is of high
scientific interest to the mission.

756
00:55:52,960 --> 00:55:56,880
Now that the primary and backup sites
have been chosen, OSIRIS-REx is

757
00:55:56,880 --> 00:56:00,240
performing additional reconnaissance
flights to prepare for the sample

758
00:56:00,240 --> 00:56:03,920
collection event. Later in 2020 the spacecraft will

759
00:56:03,920 --> 00:56:07,760
descend to Bennu's surface, briefly touch down and collect up to

760
00:56:07,760 --> 00:56:12,720

four and a half pounds of loose material. After collection OSIRIS-REx

761
00:56:12,720 --> 00:56:16,720
will carefully stow the sample
and make the long journey back to Earth.

762
00:56:16,720 --> 00:56:20,319
In late 2023 it will return the sample, delivering

763
00:56:20,319 --> 00:56:23,280
pristine material from the origins of the solar system

764
00:56:23,280 --> 00:56:26,460
that will be studied on Earth for decades to come.

765
00:56:26,460 --> 00:58:14,240
[music]

766
00:58:15,840 --> 00:58:23,520
[helicopter]

767
00:58:25,600 --> 00:58:29,440
My land cover career really started in
2002

768
00:58:29,599 --> 00:58:33,280
with biggest wildfire in Oregon's
history, and that was the Biscuit

769
00:58:33,280 --> 00:58:37,359
Wildfire. I at the time was doing botany surveys

770
00:58:37,359 --> 00:58:39,760
and looking for rare plants or rare

771
00:58:39,760 --> 00:58:42,160
mushrooms, and so I was spending a lot of
time

772
00:58:42,160 --> 00:58:46,079
out on the on the forest looking at and taking photos

773
00:58:46,079 --> 00:58:50,160
and doing the documentation that a
scientist or a land manager does.

774
00:58:50,160 --> 00:58:53,200
When that fire happened, it changed everything

775
00:58:53,200 --> 00:58:57,440
because we all had to react to this fire that was burning up

776
00:58:57,440 --> 00:59:01,119
some of the places that I'd literally been the day before.

777
00:59:01,119 --> 00:59:04,319
And it was mapping what was there and
what was under threat,

778
00:59:04,319 --> 00:59:07,440
but it was also mapping the effects of the fire.

779
00:59:07,440 --> 00:59:11,359
We needed to find a way to look across 500,000 acres,

780
00:59:11,359 --> 00:59:14,960
and the only way that we could really do
that was satellite data.

781
00:59:14,960 --> 00:59:18,480
If we can't get out and actually measure every single thing,

782
00:59:18,480 --> 00:59:22,720
what are we missing? And that's where
citizen scientists can actually come in

783
00:59:22,720 --> 00:59:25,760

and really help traditional scientists to better

784
00:59:25,760 --> 00:59:31,360
understand what is happening around them but also fill in these gaps.

785
00:59:33,040 --> 00:59:34,720
The Global Learning and Observations to

786
00:59:34,720 --> 00:59:37,760
Benefit the Environment Program
is an international science and

787
00:59:37,760 --> 00:59:42,079
education program. It provides students
and the public with the opportunity to

788
00:59:42,079 --> 00:59:46,880
participate in data collection
and the scientific process. The GLOBE

789
00:59:46,880 --> 00:59:49,359
Observer app is one of these opportunities allowing

790
00:59:49,359 --> 00:59:53,280
citizen scientists and students to take
land cover observations around the world

791
00:59:53,280 --> 00:59:56,960
and submit them to a larger database.

792
00:59:57,599 --> 01:00:02,960
But what exactly is land cover?
Dr. Eric Brown DeCoulston of NASA's

793
01:00:02,960 --> 01:00:06,880
Goddard Space Flight Center explains.
Land cover is really the basic form of

794
01:00:06,880 --> 01:00:14,079

the landscape that we have around us.
So whether it's a forest or a desert, but

795
01:00:14,079 --> 01:00:19,520
it's really one of the components of the
landscape that we can study from space.

796
01:00:19,520 --> 01:00:23,440
Peder Nelson is a scientist who uses
land cover imagery in his research

797
01:00:23,440 --> 01:00:26,559
I am a remote sensing scientist who studies

798
01:00:26,559 --> 01:00:32,880
land cover across the globe. I use satellite imagery to make maps of

799
01:00:32,880 --> 01:00:37,839
land cover and try to quantify what covers the Earth.

800
01:00:37,839 --> 01:00:42,160
Sometimes the satellite can't see what's
happening underneath the tree canopy or

801
01:00:42,160 --> 01:00:45,920
what's happening underneath cloud cover, and so we really need people

802
01:00:45,920 --> 01:00:49,599
to go out there and to take these photos
to do these observations

803
01:00:49,599 --> 01:00:54,000
to help fill in where a satellite can't
actually make some observations.

804
01:00:54,000 --> 01:00:57,920
Just like any digital photograph, land cover images are made up of a series of

805
01:00:57,920 --> 01:01:02,240

pixels to show what covers the Earth. A pixel or picture elements is the

806
01:01:02,240 --> 01:01:06,000
smallest unit of a digital image.
When combined with thousands of other

807
01:01:06,000 --> 01:01:11,200
pixels, a picture is formed. Each pixel color shown represents a land

808
01:01:11,200 --> 01:01:14,400
cover type. It's from these pixels where ground

809
01:01:14,400 --> 01:01:18,160
verification or ground truthing come into play.

810
01:01:18,160 --> 01:01:21,359
You see, depending on what satellite is taking images,

811
01:01:21,359 --> 01:01:26,480
a pixel can cover roughly an area 30 to
500 meters squared.

812
01:01:26,480 --> 01:01:29,680
For imagery captured by Landsat, a pixel
is 30 meters squared,

813
01:01:29,680 --> 01:01:35,920
or about the size of a baseball diamond.
However, part of the pixel showing forest

814
01:01:35,920 --> 01:01:40,559
might actually be water or shrubs.

815
01:01:40,720 --> 01:01:44,319
By taking land cover observations, citizen scientists can help

816
01:01:44,319 --> 01:01:48,480
answer these questions when it comes to
land cover maps.

817
01:01:48,480 --> 01:01:53,599
So why are these land cover observations so important?

818
01:01:53,599 --> 01:01:57,200
Why are they taken in the first place?

819
01:01:57,599 --> 01:02:01,599
We also are looking at how these components are changing over time

820
01:02:01,599 --> 01:02:05,599
So deforestation in the Amazon or across the world,

821
01:02:05,599 --> 01:02:09,680
how are cities expanding, a lot of different things to study

822
01:02:09,680 --> 01:02:13,440
and and really the view from space is
the way that we do it here in NASA.

823
01:02:13,440 --> 01:02:19,520
We have big supercomputers that simulate
the physics of the atmosphere and the

824
01:02:19,520 --> 01:02:23,200
land, the interaction between the Earth's systems.

825
01:02:23,200 --> 01:02:27,520
It's important to have that you know
that land cover map.

826
01:02:27,520 --> 01:02:32,960
It sets certain parameters. Those models
can actually be used to look at

827
01:02:32,960 --> 01:02:37,839
current day conditions and weather. So based on these current conditions,

828

01:02:37,839 --> 01:02:43,359
what might the Earth look like 50 or 100 years from now?

829
01:02:43,359 --> 01:02:50,079
There's an element of understanding
but then also being able to predict into

830
01:02:50,079 --> 01:02:53,520
the future, you know, what that might be like, what

831
01:02:53,520 --> 01:02:55,840
these changes may mean for us.

832
01:02:56,240 --> 01:03:01,120
Each point shown here represents a real-world measurement of environmental conditions.

833
01:03:01,280 --> 01:03:04,720
Scientists use computer models to fill in
information where measurements may not

834
01:03:04,720 --> 01:03:07,920
exist. By verifying the satellite imagery and

835
01:03:07,920 --> 01:03:11,520
using the data for these models,
scientists can predict changes in our

836
01:03:11,520 --> 01:03:15,680
environment more accurately.
One of these scientists using land cover

837
01:03:15,680 --> 01:03:19,599
maps to track urbanization as part of
her work is Dr. Amita Mehta of NASA's

838
01:03:19,599 --> 01:03:24,640
Goddard Space Flight Center.
So urbanization changes terrain

839

01:03:24,640 --> 01:03:28,240
as well as characteristics of the surface itself and so

840
01:03:28,240 --> 01:03:33,599
impervious surface is what we look at
when we are monitoring flooding.

841
01:03:33,599 --> 01:03:37,119
When there are say parking lots or
cement and concrete surfaces they

842
01:03:37,119 --> 01:03:41,200
increase, so previously if it was a farmland or

843
01:03:41,200 --> 01:03:45,359
something which was not built and if that is built now

844
01:03:45,359 --> 01:03:48,720
that water previously that could go or percolate

845
01:03:48,720 --> 01:03:55,200
in the soil and in the ground now cannot go in and it stays there.

846
01:03:55,200 --> 01:04:01,599
Monitoring helps you to plan for it.
If you see land cover changing, even then

847
01:04:01,599 --> 01:04:03,599
you know that you know how water is going to flow in

848
01:04:03,599 --> 01:04:08,240
that region might change. If you have to send rescue out or to

849
01:04:08,240 --> 01:04:13,039
plan for relief activities. Then if you know land cover

850
01:04:13,039 --> 01:04:17,359
then you know where there might be help needed.

851
01:04:17,359 --> 01:04:21,520
By using land cover maps and models that reflect changes over time

852
01:04:21,520 --> 01:04:26,400
scientists can predict where flooding
and other events may occur.

853
01:04:28,240 --> 01:04:32,000
With a changing climate these
predictions from models and land cover

854
01:04:32,000 --> 01:04:34,240
maps can help scientists better understand

855
01:04:34,240 --> 01:04:38,880
these changes and help communities prepare for them.

856
01:04:38,880 --> 01:04:43,200
But perhaps a more important reason as
to why take land cover observations

857
01:04:43,200 --> 01:04:47,200
is you get to participate in a community of scientists,

858
01:04:47,200 --> 01:04:52,960
citizen scientists and students.
So it's a very important component that

859
01:04:52,960 --> 01:04:56,160
the citizen science and students of the GLOBE program and

860
01:04:56,160 --> 01:05:01,680
GLOBE Observer can contribute to is by really giving us the information

861
01:05:01,680 --> 01:05:06,160
on the ground of what they're seeing
around them and in front of them, and we

862

01:05:06,160 --> 01:05:10,240
hope over time as well, how maybe some of these things are changing

863
01:05:10,240 --> 01:05:13,520
because those would be very valuable for science.

864
01:05:13,520 --> 01:05:19,599
I saw the value of having information
before a hazard happens. Because once

865
01:05:19,599 --> 01:05:24,640
that fire went through an area,
we could never recreate that data

866
01:05:24,640 --> 01:05:28,240
This is all important for us to share
and put together because

867
01:05:28,240 --> 01:05:32,960
that's how we understand Earth as a
system. All of these things end up

868
01:05:32,960 --> 01:05:36,720
affecting where we live, why we live where we do,

869
01:05:36,720 --> 01:05:40,880
and why we make some of the choices that we do.

870
01:05:40,880 --> 01:05:45,760
To learn more about GLOBE Observer check out the website at observerdeckglobe.gov

871
01:05:45,760 --> 01:05:49,280
and download the app to start taking
your own observations today.

872
01:05:49,560 --> 01:05:57,080
[music]

873
01:05:57,520 --> 01:06:01,200

So you want to visit a black hole. You've
packed your bags, you've updated your

874
01:06:01,200 --> 01:06:03,280
passport, and you're basically ready to jump on a

875
01:06:03,280 --> 01:06:06,160
spaceship and blast off. However before you do that,

876
01:06:06,160 --> 01:06:10,960
I have just one piece of advice: Don't.

877
01:06:14,000 --> 01:06:18,480
Okay, if you really must go, I suppose you should at least know a few

878
01:06:18,480 --> 01:06:20,880
things about black holes before you leave.

879
01:06:20,880 --> 01:06:24,880
First you should know exactly what a
black hole is. A black hole is a physical

880
01:06:24,880 --> 01:06:27,760
object in space just like everything else. It's made up

881
01:06:27,760 --> 01:06:30,960
of a tiny but massive point where
gravity and density are infinite,

882
01:06:30,960 --> 01:06:34,960
a line beyond which everything including
light can only fall into that tiny point

883
01:06:34,960 --> 01:06:37,839
and sometimes some glowing stuff
orbiting around it and maybe some

884
01:06:37,839 --> 01:06:42,000
radiation. So basically here is kind of bad. Here is

885
01:06:42,000 --> 01:06:45,920
really bad, and here is safe. Also black holes mostly

886
01:06:45,920 --> 01:06:49,520
come in two sizes. Don't ask me why, we still aren't sure.

887
01:06:49,520 --> 01:06:53,200
However, a black hole is also not a lot of things.

888
01:06:53,200 --> 01:06:57,599
It is not a hole, a cosmic vacuum cleaner,
a portal to another dimension populated

889
01:06:57,599 --> 01:07:01,520
by unicorns and space potatoes
and absolutely not a good place to

890
01:07:01,520 --> 01:07:06,319
vacation. Okay fine, I guess next you'll need to

891
01:07:06,319 --> 01:07:09,839
know how to find a black hole.
Though technically black holes could

892
01:07:09,839 --> 01:07:11,920
just sneak up behind you, they likely won't.

893
01:07:11,920 --> 01:07:14,960
The nearest known one is 3,000 light years away anyway.

894
01:07:14,960 --> 01:07:18,720
However, if you were to go looking for one,
there are a couple of good ways to find

895
01:07:18,720 --> 01:07:21,359
them. First, black holes tend to mess with

896

01:07:21,359 --> 01:07:24,319
their environment, so you can sometimes
use interesting clues

897
01:07:24,319 --> 01:07:27,599
such as a bunch of stuff orbiting what appears to be nothing.

898
01:07:27,599 --> 01:07:31,039
And second, as we mentioned before,
there's often glowing stuff orbiting

899
01:07:31,039 --> 01:07:34,799
around them caused by, well, when things get too close.

900
01:07:34,799 --> 01:07:37,920
So now that you've found a black hole
and clearly aren't listening to me

901
01:07:37,920 --> 01:07:40,839
saying not to go, it's time for a few important safety

902
01:07:40,839 --> 01:07:44,559
considerations. First of all the good news is that as

903
01:07:44,559 --> 01:07:49,119
long as you stay far away, black holes aren't that bad. However as you

904
01:07:49,119 --> 01:07:51,599
get closer, you need to keep a few things in mind.

905
01:07:51,599 --> 01:07:54,799
The radiation near the black hole can be
extremely deadly, but the chances of

906
01:07:54,799 --> 01:07:58,720
escape get slimmer the closer you get.
And if you get close enough you now have

907
01:07:58,720 --> 01:08:02,020

to worry about being stretched into a
giant noodle and time getting really weird.

908
01:08:02,100 --> 01:08:04,319
So unless you have great radiation

909
01:08:04,319 --> 01:08:08,079
shields, a faster than light spaceship,
or you're completely indestructible, you

910
01:08:08,079 --> 01:08:12,559
should probably just stay away.
Well that pretty much sums up black

911
01:08:12,559 --> 01:08:15,359
holes. At least before things start
getting really complicated.

912
01:08:15,359 --> 01:08:19,040
But before you go for real, please refer
to the handy brochure on your spacesuit

913
01:08:19,040 --> 01:08:21,040
pocket since there's quite a bit to remember.

914
01:08:21,040 --> 01:08:26,160
Now then remember your tickets enjoy
your trip and please be careful.

915
01:08:27,040 --> 01:08:37,840
[music]

916
01:08:38,520 --> 01:08:41,040
A hurricane is mother nature's grandest

917
01:08:41,040 --> 01:08:43,820
but most ferocious weather machine.

918
01:08:44,020 --> 01:08:45,460

A hurricane is two different things.

919
01:08:45,540 --> 01:08:46,560
If you're looking at it from

920
01:08:46,560 --> 01:08:52,480
above from the satellite down, a hurricane
is a beautiful thing. It's a massive coil

921
01:08:52,480 --> 01:08:56,239
of clouds that is rotating, spinning like a top.

922
01:08:56,239 --> 01:08:59,920
When I look at images of hurricanes, I go
through so many

923
01:08:59,920 --> 01:09:04,159
emotions. As a scientist, as a
meteorologist, I'm like

924
01:09:04,160 --> 01:09:09,080
wow, this is fascinating you know look at
this beautiful storm.

925
01:09:11,360 --> 01:09:15,279
But then the human side of me is saying how can we

926
01:09:15,279 --> 01:09:19,279
make sure that people are evacuating, that people

927
01:09:19,279 --> 01:09:23,440
have somewhere to stay, that they have
the money to feed their families once

928
01:09:23,440 --> 01:09:28,560
they leave their homes.
The hurricane on the ground, that's a

929
01:09:28,560 --> 01:09:32,719

completely different thing because all of that rotation, you really

930
01:09:32,719 --> 01:09:36,000
feel as incredibly severe winds. They can be up

931
01:09:36,000 --> 01:09:42,799
to 150 or more miles per hour.
You can have up to 40 inches of rain and

932
01:09:42,799 --> 01:09:46,640
the most deadly thing is that the updraft from the hurricane

933
01:09:46,640 --> 01:09:53,860
is actually pulling ocean swell up into it and so it creates a storm surge up to 40 feet high.

934
01:09:54,700 --> 01:09:57,600
And occasionally when the storms hit at

935
01:09:57,600 --> 01:10:00,640
a little higher latitude, they can also spawn tornadoes in their

936
01:10:00,640 --> 01:10:03,840
fringe. So really the impacts are the the
wind,

937
01:10:03,840 --> 01:10:08,320
the storm surge, the heavy rainfall and
then occasionally severe weather

938
01:10:08,320 --> 01:10:13,199
that forms when they move inland. I feel
like I got a deeper appreciation for

939
01:10:13,199 --> 01:10:18,800
hurricanes when I moved to Galveston, Texas. That entire city,

940
01:10:18,800 --> 01:10:22,560
it's almost like the ghosts of the 1900
hurricane that are still there

941
01:10:22,560 --> 01:10:26,960
because you see evidence of that storm, that particular

942
01:10:26,960 --> 01:10:32,000
famous storm that killed somewhere
between 6,000 and 12,000 people,

943
01:10:32,000 --> 01:10:35,120
and so that is a very present you know thing

944
01:10:35,120 --> 01:10:41,840
in the city even to this day.
So that was a category 4 storm that hit

945
01:10:41,840 --> 01:10:45,920
Galveston on September 8th, and there
really was not a lot of information

946
01:10:45,920 --> 01:10:50,640
about what was happening in the Caribbean before the storm made landfall.

947
01:10:50,820 --> 01:10:52,640
And the hurricane hit them totally

948
01:10:52,640 --> 01:10:57,280
unprepared and thousands of people lost
their lives. Tremendous damage because it

949
01:10:57,280 --> 01:11:02,880
surprised everyone. With the onsets of satellites

950
01:11:02,880 --> 01:11:06,700
that will never happen.

951
01:11:06,700 --> 01:11:09,679
The first leap forward would have been

952

01:11:09,679 --> 01:11:13,280
being able to see the entire planet from space in the first place.

953
01:11:13,280 --> 01:11:18,400
Prior to that how would you know for
example that a hurricane was coming?

954
01:11:18,400 --> 01:11:21,199
It would have been very difficult to
know that where it was coming, where it

955
01:11:21,199 --> 01:11:26,800
was going, how bad it was going to be.
So that's one of the dramatic impacts is

956
01:11:26,800 --> 01:11:30,320
satellite data, sort of like your eyes in the sky to

957
01:11:30,320 --> 01:11:33,700
make sure that mother nature never can surprise you.

958
01:11:33,900 --> 01:11:37,679
You know when I was a child I loved playing with magnifying glasses because

959
01:11:37,679 --> 01:11:41,199
you can zoom in you know and see so many fine details.

960
01:11:41,199 --> 01:11:44,400
And that's what we can do with the
satellites that we have now, particularly

961
01:11:44,400 --> 01:11:47,760
the GOES-R series. We're getting 60 times more data

962
01:11:47,760 --> 01:11:51,840
now than what we were in the previous series

963
01:11:51,840 --> 01:11:54,480
You know the first satellites I worked

at the GOES I through M, which were great

964
01:11:54,480 --> 01:11:57,520
satellites, but taking a picture of the globe every 25

965
01:11:57,520 --> 01:12:00,159
minutes, you know the hurricanes would be like here

966
01:12:00,159 --> 01:12:03,600
and then they're here and then they're
here. And it's not like you're losing

967
01:12:03,600 --> 01:12:06,159
track of them, but the difference between that and

968
01:12:06,159 --> 01:12:10,159
being able to see you know oh it's
swerving, it's curling, oh it's you know

969
01:12:10,159 --> 01:12:13,760
it's dying. We take a full disc picture of the

970
01:12:13,760 --> 01:12:16,800
entire hemisphere in five minutes, but we can also look at

971
01:12:16,800 --> 01:12:21,920
smaller areas, and you can scan that
once every 30 seconds. You get to see as

972
01:12:21,920 --> 01:12:24,880
the hurricane eyewall was forming. You can see that

973
01:12:24,880 --> 01:12:28,640
actually forming in real time. The Earth looks alive,

974
01:12:28,640 --> 01:12:31,340
it looks like a living thing.

975

01:12:34,160 --> 01:12:38,320
So the polar opening satellites
complement the geostationary.

976
01:12:38,320 --> 01:12:41,679
Since the geostationary like 24,000 miles up,

977
01:12:41,679 --> 01:12:45,840
while they get great pictures it's
really hard to measure

978
01:12:45,840 --> 01:12:49,199
what is the state of the atmosphere from that distance.

979
01:12:49,199 --> 01:12:53,760
So the polar orbiting are basically
flying a little over 500 miles

980
01:12:53,760 --> 01:12:57,679
up, and when you're at that altitude you can

981
01:12:57,679 --> 01:13:02,239
sense what's in the atmosphere to a lot higher resolution.

982
01:13:02,239 --> 01:13:07,679
The JPSS satellite is really primary purpose is to take measurements

983
01:13:07,679 --> 01:13:10,560
of the temperature and moisture of the atmosphere

984
01:13:10,560 --> 01:13:14,480
to drive the weather forecast models.

985
01:13:15,360 --> 01:13:18,560
Two things people always want to know about hurricanes are

986
01:13:18,560 --> 01:13:21,920
how strong is it and where is it going to hit.

987
01:13:21,920 --> 01:13:26,320
And microwave sounders can certainly help with both of those.

988
01:13:26,320 --> 01:13:30,080
The ability to see through clouds becomes really important.

989
01:13:30,080 --> 01:13:33,840
If you've ever seen a picture of a hurricane from space,

990
01:13:33,840 --> 01:13:37,280
mostly what you're seeing is clouds and you can

991
01:13:37,280 --> 01:13:40,560
get a better weather forecast or better
prediction of how strong the hurricane is

992
01:13:40,560 --> 01:13:42,880
and where it's going to hit, which

993
01:13:42,880 --> 01:13:45,440
direction it's going to go, if you could see through those clouds.

994
01:13:45,440 --> 01:13:49,520
And see the structure of the atmosphere,
maybe even the ocean conditions

995
01:13:49,520 --> 01:13:55,800
underneath that, and so microwave sensors allow you to to do that kind of thing.

996
01:13:56,400 --> 01:13:59,520
As you've seen when they do the
hurricane forecasting they there's

997
01:13:59,520 --> 01:14:02,400
usually a cone of uncertainty they put in the path.

998
01:14:02,400 --> 01:14:06,800
We don't know exactly where it's going,

but for the next three days or five days

999
01:14:06,800 --> 01:14:10,880
or seven days, here's the cone that it could go in.

1000
01:14:10,880 --> 01:14:14,480
But you don't want to overwarn right? You don't want to

1001
01:14:14,480 --> 01:14:19,760
have the whole East Coast running inland 100 miles because of a hurricane,

1002
01:14:19,760 --> 01:14:23,520
potential hurricane. You'd like that as precise as you can so

1003
01:14:23,520 --> 01:14:26,080
that only the people who are really going to be affected

1004
01:14:26,080 --> 01:14:30,400
have to do something. The improved sensors that we've been

1005
01:14:30,400 --> 01:14:35,040
flying allow a better understanding of the core of that hurricane

1006
01:14:35,040 --> 01:14:38,159
and allow the forecasters to better predict precisely

1007
01:14:38,159 --> 01:14:42,400
where that hurricane is going to hit. And
when they do that then you can narrow

1008
01:14:42,400 --> 01:14:47,060
and shrink that cone of uncertainty and give a better prediction.

1009
01:14:47,360 --> 01:14:49,120
We hope to continue to improve the

1010
01:14:49,120 --> 01:14:52,880
ability to do track forecasting.

That's gotten so much better over the

1011
01:14:52,880 --> 01:14:57,280
past couple of decades. Our five-day forecast is about as accurate

1012
01:14:57,280 --> 01:15:01,360
as our two-day forecast was only about 20 years ago

1013
01:15:02,560 --> 01:15:06,719
And increasingly people are listening to the forecasts that they get from

1014
01:15:06,719 --> 01:15:10,000
meteorologists. They have increased
confidence, they see the improvement

1015
01:15:10,000 --> 01:15:14,560
in forecasts as it relates to hurricanes
over the last couple of decades,

1016
01:15:14,560 --> 01:15:18,080
and when a hurricane watch or hurricane
warning goes into effect,

1017
01:15:18,080 --> 01:15:22,640
people take notice and they take action, and that's really encouraging to see.

1018
01:15:32,040 --> 01:15:39,600
[music]

1019
01:15:40,160 --> 01:15:44,320
NASA's TESS mission has found its first
Earth-sized world in its star's

1020
01:15:44,320 --> 01:15:48,960
habitable zone. This means the planet called TOI700d

1021
01:15:48,960 --> 01:15:52,800
has the potential for liquid water on its surface.

1022
01:15:52,800 --> 01:15:57,199
TESS stares at patches of sky for long
stretches recording light from thousands

1023
01:15:57,199 --> 01:16:00,400
of stars. Some of these stars have planets that

1024
01:16:00,400 --> 01:16:05,760
cross or transit in front of them.
TESS sees these events as tiny regular

1025
01:16:05,760 --> 01:16:10,880
dimmings of the host's stars.
One star where TESS saw transits is

1026
01:16:10,880 --> 01:16:14,320
TOI700. It's a red dwarf about 40 percent the

1027
01:16:14,320 --> 01:16:19,199
mass and size of our Sun and roughly half its temperature. One set

1028
01:16:19,199 --> 01:16:22,480
of transits announced the presence of a
planet close to the star,

1029
01:16:22,480 --> 01:16:27,679
called TOI 700b. Another set revealed a second planet

1030
01:16:27,679 --> 01:16:32,239
named TOI 700c a little farther out. The deeper, shorter

1031
01:16:32,239 --> 01:16:34,719
transit means the planet is larger than the first

1032
01:16:34,719 --> 01:16:37,840
and the plane of its orbit is slightly tipped.

1033
01:16:37,840 --> 01:16:44,560

A final set of transits showed TOI 700d
orbiting even farther out. TESS observed

1034
01:16:44,560 --> 01:16:48,000
the system for nearly 11 months and saw
each planet transit

1035
01:16:48,000 --> 01:16:52,800
multiple times. Scientists determined
that the inner and outer planets are

1036
01:16:52,800 --> 01:16:56,400
almost Earth-size and may be rocky. The middle world is

1037
01:16:56,400 --> 01:17:00,640
more than twice as large and most likely made of gas. All three

1038
01:17:00,640 --> 01:17:03,920
may be tidally locked, rotating just once each orbit.

1039
01:17:03,920 --> 01:17:10,000
So the same side always faces the star,
but most importantly TOI 700d

1040
01:17:10,000 --> 01:17:14,800
is within the star's habitable zone.
Scientists wanted independent

1041
01:17:14,800 --> 01:17:19,440
confirmation of TOI 700d
so they monitored its star with NASA's

1042
01:17:19,440 --> 01:17:23,440
Spitzer Space Telescope. Spitzer saw a clear transit from the

1043
01:17:23,440 --> 01:17:27,600
outer planet affirming its existence and
improving scientist certainty of the

1044

01:17:27,600 --> 01:17:32,640
planet's size. TOI 700d is one of only a few

1045
01:17:32,640 --> 01:17:36,239
Earth-sized planets found in potential
habitable zones.

1046
01:17:36,239 --> 01:17:42,239
Others include discoveries by Kepler and
several planets in the TRAPPIST-1 system.

1047
01:17:42,239 --> 01:17:47,199
Because TOI 700 is bright and nearby
the planets are good candidates for

1048
01:17:47,199 --> 01:17:51,280
precise mass measurements by
ground-based telescopes.

1049
01:17:51,280 --> 01:17:54,640
Future missions may also tell us if the worlds have atmospheres,

1050
01:17:54,640 --> 01:17:58,400
but scientists need to know what kinds of signals to look for.

1051
01:17:58,400 --> 01:18:02,159
Researchers at NASA's Goddard Space Flight Center created models of the

1052
01:18:02,159 --> 01:18:05,120
planet to explore its potential conditions.

1053
01:18:05,120 --> 01:18:09,520
One version is a water covered world
with an atmosphere similar to early Mars,

1054
01:18:09,520 --> 01:18:12,560
but denser. Another looks like a completely dry

1055
01:18:12,560 --> 01:18:17,440

version of today's Earth.
Both models have vastly different

1056
01:18:17,440 --> 01:18:21,120
surface temperatures.
Light passing through their atmospheres

1057
01:18:21,120 --> 01:18:26,080
creates distinct signals because
different molecules are present.

1058
01:18:26,080 --> 01:18:29,679
By simulating these data now scientists can make predictions for real

1059
01:18:29,679 --> 01:18:33,840
future observations and narrow the range of TOI 700d's

1060
01:18:33,840 --> 01:18:37,920
possible conditions.
We still have much to learn about the

1061
01:18:37,920 --> 01:18:42,320
TOI 700 system, but thanks to TESS, Spitzer and the work

1062
01:18:42,320 --> 01:18:46,000
of many scientists, we're beginning to form a picture of its

1063
01:18:46,000 --> 01:18:47,960
exciting new worlds.

1064
01:18:48,760 --> 01:18:52,920
[music]

1065
01:18:55,920 --> 01:18:57,760
The digital show NASA Explorers has a

1066
01:18:57,760 --> 01:19:01,280
few different taglines.
One of them is "We follow intrepid

1067
01:19:01,280 --> 01:19:06,719
explorers into the field." And that is true, and it's sometimes to

1068
01:19:06,719 --> 01:19:12,320
places that are remote or can be hostile.

1069
01:19:12,320 --> 01:19:16,960
We went to one location that I would not
consider remote or hostile, but it was an

1070
01:19:16,960 --> 01:19:21,060
adventure anyway. It was Boise, Idaho.

1071
01:19:21,200 --> 01:19:26,800
This mobile laboratory has been deployed for
a very specific reason: the Shady Fire is

1072
01:19:26,800 --> 01:19:30,400
burning nearby, and this team is gathering data that you

1073
01:19:30,400 --> 01:19:32,840
can only get at night.

1074
01:19:46,080 --> 01:19:50,400
We were with a team of scientists who
were tracking smoke, understanding

1075
01:19:50,400 --> 01:19:53,840
the chemistry of smoke. It was really
around the wildfire season, controlled

1076
01:19:53,840 --> 01:19:56,560
burns, but just what what smoke was doing to

1077
01:19:56,560 --> 01:19:59,199
the air, what fires were doing to the land.

1078

01:19:59,199 --> 01:20:02,239
We had the opportunity to follow this team

1079
01:20:02,239 --> 01:20:05,520
who you meet in one of the episodes, Bruce Anderson and his team

1080
01:20:05,520 --> 01:20:10,320
out of Langley. We thought, you know it was 90 degrees that day.

1081
01:20:10,320 --> 01:20:14,239
Like we're just gonna sleep in the car
and it'll be fine.

1082
01:20:14,239 --> 01:20:18,159
Hi NASA Expeditions followers, I'm Katy. I've been doing a lot of the tweeting

1083
01:20:18,159 --> 01:20:21,920
and the posting that you've been seeing
and here we have Lauren. Hi guys! And

1084
01:20:21,920 --> 01:20:25,199
driving our car we have Ellen. She's not going to talk too

1085
01:20:25,199 --> 01:20:28,239
much because she's driving. We are the communications team in the

1086
01:20:28,239 --> 01:20:31,600
field with the FIREX-AQ mission this week and we thought we'd give you a

1087
01:20:31,600 --> 01:20:35,360
little behind the scenes peek at what
it's like to be in the field

1088
01:20:35,360 --> 01:20:37,840
It'll be warm enough it'll be great
we'll just follow them throughout the

1089
01:20:37,840 --> 01:20:39,920
night as they take all these measurements.

1090
01:20:39,920 --> 01:20:46,800
So you know, almost instantly when the sun goes down,

1091
01:20:46,800 --> 01:20:50,639
the temperature drops from around 90 or
95

1092
01:20:50,639 --> 01:20:56,800
somewhere in there to 19 degrees.
We'll set out, drive up there, find a

1093
01:20:56,800 --> 01:21:01,600
place to position the van then start cranking up

1094
01:21:01,600 --> 01:21:04,880
instruments.
And we're frozen. We're absolutely frozen

1095
01:21:04,880 --> 01:21:07,920
in the car and the thing is the team is
waking up throughout the night.

1096
01:21:07,920 --> 01:21:11,679
You know the scientists collecting data,
emptying filters, and so we're trying to

1097
01:21:11,679 --> 01:21:15,199
catch all these moments. It means that there's not a lot of sleep

1098
01:21:15,199 --> 01:21:19,840
it's really cold but you have to stay somewhat awake so that you can catch the

1099
01:21:19,840 --> 01:21:24,560
team working. I think what that experience allowed us

1100
01:21:24,560 --> 01:21:27,199
to have is this real relationship with the

1101
01:21:27,199 --> 01:21:30,560
the scientists in the field.
Especially Bruce Anderson,

1102
01:21:30,560 --> 01:21:34,159
you know there's a moment where we're
talking to Bruce in the show,

1103
01:21:34,159 --> 01:21:40,560
and he's talking about how he why he does what he does and

1104
01:21:40,560 --> 01:21:44,080
I asked him this question that i you know I tend to ask most people and I

1105
01:21:44,080 --> 01:21:46,800
think it's a really common question among producers.

1106
01:21:46,800 --> 01:21:50,000
But we asked him why do you do what you
do?

1107
01:21:50,000 --> 01:21:54,719
And the response he gave was one I
probably won't ever forget

1108
01:21:54,719 --> 01:22:01,120
because it was so based in
his life experience and a genuine desire

1109
01:22:01,120 --> 01:22:07,120
to make a positive impact on the world.
For some of our scientists understanding

1110
01:22:07,120 --> 01:22:11,280
pollution has defined the course of their life's work.

1111
01:22:11,280 --> 01:22:17,360
I'm a physical chemist but I'm also from what 60 Minutes called the

1112
01:22:17,360 --> 01:22:20,239
most polluted city in America, Anderson,
Alabama.

1113
01:22:20,239 --> 01:22:24,400
When the opportunity came along to do this type of work, I really resonated

1114
01:22:24,400 --> 01:22:27,280
with it.
He of course was interested in the

1115
01:22:27,280 --> 01:22:32,320
actual science but Bruce took this incredibly seriously.

1116
01:22:32,320 --> 01:22:35,280
He decided that he was going to pursue science. He was going to

1117
01:22:35,280 --> 01:22:38,560
understand pollution all over the United States, all over the

1118
01:22:38,560 --> 01:22:42,960
world and be able to produce hard data
that could help communities make better

1119
01:22:42,960 --> 01:22:45,120
decisions about the way they wanted to live.

1120
01:22:45,120 --> 01:22:48,800
We wouldn't have gotten that story from Bruce had we not

1121
01:22:48,800 --> 01:22:55,120
spent this time with him in the field. If
we hadn't gotten to know them as people.

1122
01:22:55,120 --> 01:22:59,679
And I think being able to do NASA Explorers,

1123
01:22:59,679 --> 01:23:03,440

it presents the opportunity to be humble
about other people's stories and other

1124
01:23:03,440 --> 01:23:06,520
people's motivations to understand that they are

1125
01:23:06,520 --> 01:23:10,960
multi-dimensional people who do the things they do because

1126
01:23:10,960 --> 01:23:14,639
they're interested in science but
often there's a deeper reason and a

1127
01:23:14,639 --> 01:23:18,800
deeper connection to the science they do.
And it's our responsibility to tell them

1128
01:23:18,800 --> 01:23:23,360
with dignity and respect and we try and do that with

1129
01:23:23,360 --> 01:23:27,120
with our stories at NASA Explorers. So
that's a little behind the scenes of

1130
01:23:27,120 --> 01:23:31,680
how we got that story and how we got those shots.

1131
01:23:31,880 --> 01:23:42,080
[music]

1132
01:23:42,880 --> 01:23:46,560
Global temperatures are on the rise. As
our climate changes,

1133
01:23:46,560 --> 01:23:50,960
Earth is seeing more extreme and unusual weather.

1134
01:23:50,960 --> 01:23:56,080
In 2019 the National Audubon Society

reported that two-thirds of America's

1135
01:23:56,080 --> 01:23:59,480
birds are threatened by climate change. That's

1136
01:23:59,480 --> 01:24:05,400
389 species in danger of extinction.
Scientists at the University of

1137
01:24:05,400 --> 01:24:08,480
Wisconsin-Madison are trying to figure out how temperature

1138
01:24:08,480 --> 01:24:13,120
affects bird biodiversity across the country, which will help

1139
01:24:13,120 --> 01:24:17,920
conservationists figure out where to prioritize their efforts.

1140
01:24:17,920 --> 01:24:21,040
The team used data from Landsat's thermal sensor

1141
01:24:21,040 --> 01:24:25,600
called TIRS to map temperature across the United States.

1142
01:24:25,600 --> 01:24:30,400
They also used a computer algorithm to
map small-scale temperature differences.

1143
01:24:30,400 --> 01:24:33,679
For example, a grove of trees in an open field.

1144
01:24:33,679 --> 01:24:37,280
The algorithm compares the temperature
variability in one area

1145
01:24:37,280 --> 01:24:46,480
to those adjacent to it. The team then compared their temperature

1146

01:24:46,480 --> 01:24:49,760
data to bird biodiversity across the country,

1147
01:24:49,760 --> 01:24:54,000
focusing on the winter months and birds
that don't migrate to find warmer

1148
01:24:54,000 --> 01:24:58,239
temperatures.
Turns out large-bodied bird species tend

1149
01:24:58,239 --> 01:25:01,360
to choose places with higher overall temperatures,

1150
01:25:01,360 --> 01:25:04,480
but for small birds and climate-threatened species having a

1151
01:25:04,480 --> 01:25:08,960
habitat with variable temperatures
seems to be more important.

1152
01:25:08,960 --> 01:25:12,960
The researchers speculate that some birds
may use pockets of warmer habitat,

1153
01:25:12,960 --> 01:25:16,960
like a nest, a snow burrow or a patch of dense tree cover,

1154
01:25:16,960 --> 01:25:20,240
to wait out a cold spell or weather event.

1155
01:25:21,200 --> 01:25:25,440
In the study, temperature explained about
a third of why some areas have more bird

1156
01:25:25,440 --> 01:25:28,960
species than others, but that still leaves nearly two-thirds

1157
01:25:28,960 --> 01:25:32,480

unaccounted for. To protect many bird species from

1158
01:25:32,480 --> 01:25:38,840
extinction, scientists will have to find
other factors affecting bird biodiversity.

1159
01:25:45,280 --> 01:26:53,040
[music]

1160
01:26:54,080 --> 01:26:58,480
The Hubble Space Telescope has had five
servicing missions since its launch in

1161
01:26:58,480 --> 01:27:02,880
1990. From servicing mission 1 in 1993 to

1162
01:27:02,880 --> 01:27:07,520
servicing mission 4 in 2009. Wait, what?

1163
01:27:07,520 --> 01:27:11,520
Five servicing missions but the last one
is called servicing mission

1164
01:27:11,520 --> 01:27:16,080
four? While it might seem strange at
first, there's a reason for that,

1165
01:27:16,080 --> 01:27:20,800
and that's because servicing mission 3
has a very interesting history.

1166
01:27:20,800 --> 01:27:25,040
Originally scheduled for launch in mid-2000 Hubble's third servicing

1167
01:27:25,040 --> 01:27:28,639
mission was going to upgrade and
refurbish the telescope just as the

1168
01:27:28,639 --> 01:27:31,360

first two servicing missions had done before.

1169
01:27:31,360 --> 01:27:37,360
But in quick succession, Hubble's
all-important gyroscopes began to fail.

1170
01:27:37,360 --> 01:27:41,280
So why are Hubble's gyroscopes so important?

1171
01:27:41,280 --> 01:27:45,040
Hubble Deputy Project Manager Jim
Jeletic can explain.

1172
01:27:45,040 --> 01:27:48,080
So while we're turning Hubble we need to know exactly

1173
01:27:48,080 --> 01:27:52,400
which direction we're turning it. So we
use a sensor known as a gyroscope or a

1174
01:27:52,400 --> 01:27:55,920
gyro. They use the conservation of angular

1175
01:27:55,920 --> 01:27:59,440
momentum to tell us if Hubble is turning, in which

1176
01:27:59,440 --> 01:28:02,639
specific direction and how fast it's turning in

1177
01:28:02,639 --> 01:28:06,239
that direction.
So essentially without the gyroscopes we

1178
01:28:06,239 --> 01:28:08,800
have no way to know where Hubble is pointing,

1179
01:28:08,800 --> 01:28:12,400
which for a telescope is kind of important.

1180
01:28:12,400 --> 01:28:18,000
In 1999 Hubble needed at least three of its six gyroscopes to be running in

1181
01:28:18,000 --> 01:28:21,120
order to do science. And with only three gyros still

1182
01:28:21,120 --> 01:28:25,679
functioning, a Hubble emergency was
declared and servicing mission 3

1183
01:28:25,679 --> 01:28:30,199
was quickly split into two separate launches.

1184
01:28:30,199 --> 01:28:34,880
SM3A's main priority would be switching
out all the gyroscopes with new and

1185
01:28:34,880 --> 01:28:39,120
improved versions, while SM3B was scheduled for a few

1186
01:28:39,120 --> 01:28:41,360
years later and would work on the updates that

1187
01:28:41,360 --> 01:28:44,560
Hubble still needed but weren't as urgent.

1188
01:28:44,560 --> 01:28:49,679
Due to this timing change, the astronauts
for SM3A had less time to train for

1189
01:28:49,679 --> 01:28:53,120
their important mission, but they went into overdrive and were

1190
01:28:53,120 --> 01:28:56,840
ready in time for their launch date of October 14th, 1999.

1191
01:28:56,840 --> 01:29:02,960
However, delays caused by final inspections and wiring repairs on

1192
01:29:02,960 --> 01:29:06,880
the shuttle continued to push the launch
date deeper and deeper into the end of

1193
01:29:06,880 --> 01:29:09,920
the year. And then as if things couldn't get any

1194
01:29:09,920 --> 01:29:14,239
worse in mid-November a fourth gyroscope on Hubble failed.

1195
01:29:14,239 --> 01:29:19,120
Hubble was put into safe mode and all
science came to a screeching halt.

1196
01:29:19,120 --> 01:29:22,239
Thankfully the Hubble team had already decided to split

1197
01:29:22,239 --> 01:29:27,040
SM3 into two missions months earlier. Otherwise Hubble would have been totally

1198
01:29:27,040 --> 01:29:30,719
silent until the originally planned mid-2000 mission.

1199
01:29:30,719 --> 01:29:34,960
So after a few more delays due to more inspections, rewiring,

1200
01:29:34,960 --> 01:29:38,880
engine replacements and bad weather, the crew of SM3A

1201
01:29:38,880 --> 01:29:43,600
sitting in the cockpit of the Space Shuttle Discovery was ready to launch.

1202
01:29:43,600 --> 01:29:46,639
The eight-day mission had three spacewalks planned.

1203
01:29:46,639 --> 01:29:50,560
The first was the all-important gyro switch-out. There were a few minor

1204
01:29:50,560 --> 01:29:55,040
problems that came up during the 8 hour 15 minute long spacewalk, but

1205
01:29:55,040 --> 01:29:59,600
by the end of the day, Hubble's gyro troubles were over.

1206
01:29:59,600 --> 01:30:03,840
The next two days had their own spacewalks, updating Hubble with a more

1207
01:30:03,840 --> 01:30:07,280
advanced computer, adding a new fine guidance sensor,

1208
01:30:07,280 --> 01:30:11,360
installing a new solid-state digital recorder and replacing Hubble's

1209
01:30:11,360 --> 01:30:15,760
old outer insulation with new panels in order to protect Hubble's scientific

1210
01:30:15,760 --> 01:30:20,960
equipment from getting too hot or too cold. When all the work was finished

1211
01:30:20,960 --> 01:30:24,000
Hubble was released back into orbit on
Christmas Day,

1212
01:30:24,000 --> 01:30:28,080
and as the crew of Discovery landed at
Kennedy Space Center, it became clear

1213
01:30:28,080 --> 01:30:31,760
that this mission was a resounding success.

1214
01:30:31,760 --> 01:30:34,960
Servicing Mission 3B would also be a success

1215
01:30:34,960 --> 01:30:41,199
later in march of 2002, followed by the

fifth and final flight Servicing Mission 4

1216
01:30:41,199 --> 01:30:46,000
in May of 2009.
Thanks to everyone involved with

1217
01:30:46,000 --> 01:30:49,920
Servicing Mission 3A, Hubble was able to quickly get back on

1218
01:30:49,920 --> 01:30:54,560
schedule with its groundbreaking science
and continue forward with its mission of

1219
01:30:54,560 --> 01:30:59,440
uncovering the mysteries of the universe.