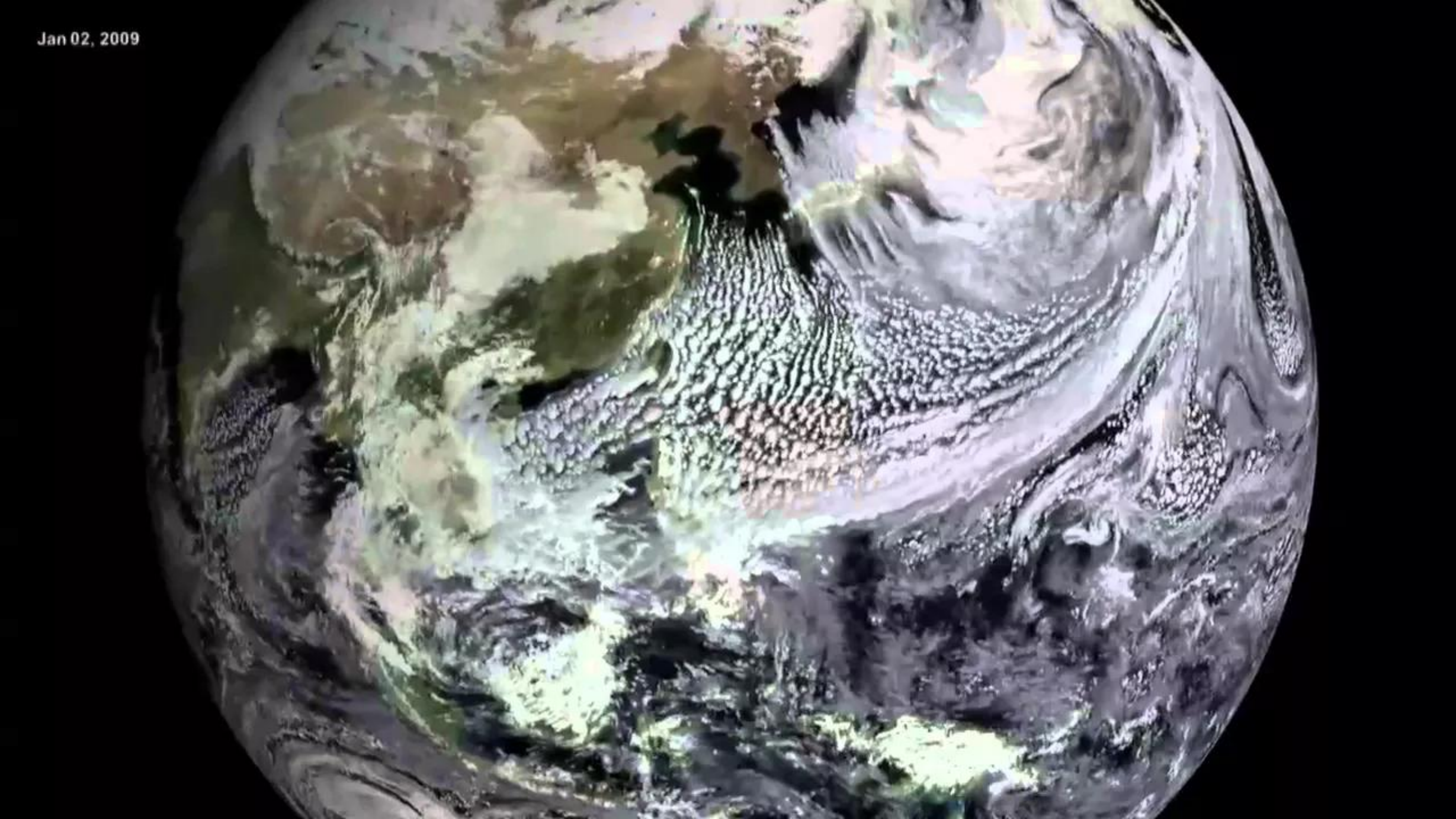
Jan 02, 2009

1
00:00:18,240 --> 00:00:15,930
hello and welcome to the National Air

2
00:00:20,250 --> 00:00:18,250
and Space Museum I am dr. Jennifer

3
00:00:22,050 --> 00:00:20,260
Levasseur a curator here in our

4
00:00:24,120 --> 00:00:22,060
Department of space history and I want

5
00:00:25,550 --> 00:00:24,130
to welcome all of you to what's new in

6
00:00:28,560 --> 00:00:25,560
aerospace our program this afternoon

7
00:00:30,570 --> 00:00:28,570
today we are celebrating Earth Day as

8
00:00:32,910 --> 00:00:30,580
well as the 25th anniversary of the

9
00:00:34,380 --> 00:00:32,920
Hubble Space Telescope and we have dr.

10
00:00:36,689 --> 00:00:34,390
Pierce Sellars with us who's going to

11
00:00:38,250 --> 00:00:36,699
talk about seeing Earth from space he's

12
00:00:40,740 --> 00:00:38,260
going to give us a tour of Earth from

13
00:00:42,329 --> 00:00:40,750

the astronauts perspective and also show

14
00:00:44,790 --> 00:00:42,339
us what we can learn about our planet

15
00:00:46,320 --> 00:00:44,800
from orbit I want to remember every I

16
00:00:48,630 --> 00:00:46,330
want to remind everyone who is watching

17
00:00:50,910 --> 00:00:48,640
online or on NASA television too so

18
00:00:53,939 --> 00:00:50,920
please submit your questions and we can

19
00:00:55,259 --> 00:00:53,949
answer them later in the show now I want

20
00:00:57,899 --> 00:00:55,269
to introduce our speaker today dr.

21
00:00:59,910 --> 00:00:57,909
Sellars was born in Sussex England and

22
00:01:01,829 --> 00:00:59,920
before he went to university he would be

23
00:01:04,170 --> 00:01:01,839
K he trained as a pilot with the Royal

24
00:01:06,300 --> 00:01:04,180
Air Force he earned a Bachelor of

25
00:01:09,060 --> 00:01:06,310
Science degree in ecological science at

26
00:01:11,010 --> 00:01:09,070
the University of Edinburgh and a PhD in

27
00:01:13,440 --> 00:01:11,020
biomaterial adji from the University of

28
00:01:15,870 --> 00:01:13,450
Leeds he moved to the United States in

29
00:01:17,730 --> 00:01:15,880
1982 to work at the NASA Goddard Space

30
00:01:19,800 --> 00:01:17,740
Flight Center which of course is just up

31
00:01:22,709 --> 00:01:19,810
the road from us and he was there as a

32
00:01:24,690 --> 00:01:22,719
research meteorologist I would say he is

33
00:01:26,840 --> 00:01:24,700
the model of persistence having applied

34
00:01:29,880 --> 00:01:26,850
many times to the astronaut program

35
00:01:32,819 --> 00:01:29,890
starting in 1984 and finally being

36
00:01:35,219 --> 00:01:32,829
accepted in 1996 as part of the largest

37
00:01:36,989 --> 00:01:35,229
class of astronauts ever nicknamed the

38
00:01:39,989 --> 00:01:36,999

sardines because there were 44

39
00:01:43,469 --> 00:01:39,999
astronauts in the class he's flown to

40
00:01:46,080 --> 00:01:43,479
space three times on the space shuttle

41
00:01:49,349 --> 00:01:46,090
and spent almost 35 days in space he

42
00:01:51,200 --> 00:01:49,359
twice flew on Atlantis in 2002 and 2010

43
00:01:53,700 --> 00:01:51,210
to the International Space Station and

44
00:01:56,789 --> 00:01:53,710
most importantly to us here at the

45
00:01:59,609 --> 00:01:56,799
museum flew on discovery in 2006 to the

46
00:02:01,379 --> 00:01:59,619
International Space Station on his 2010

47
00:02:04,620 --> 00:02:01,389
mission he did a special task for us

48
00:02:08,100 --> 00:02:04,630
here at the museum he flew the replica

49
00:02:09,900 --> 00:02:08,110
of a nobel prize won by john mavar from

50
00:02:11,610 --> 00:02:09,910
our collection to space and returned to

51
00:02:14,250 --> 00:02:11,620
us quite generously at the end of his

52
00:02:17,160 --> 00:02:14,260
mission he performed six spacewalks

53
00:02:19,650 --> 00:02:17,170
totaling over 41 hours having been spent

54
00:02:24,780 --> 00:02:19,660
outside his spacecraft so let's welcome

55
00:02:30,310 --> 00:02:27,220
thank you very much well good afternoon

56
00:02:32,080 --> 00:02:30,320
everybody it's great to be here and I'm

57
00:02:34,780 --> 00:02:32,090
going to give you a quick tour of the

58
00:02:36,640 --> 00:02:34,790
Earth from space anybody here like to go

59
00:02:39,700 --> 00:02:36,650
into space I'm looking at the back there

60
00:02:41,800 --> 00:02:39,710
yes good answer yeah the view is

61
00:02:43,110 --> 00:02:41,810
terrific so I'm going to talk about

62
00:02:50,020 --> 00:02:43,120
planet Earth

63
00:02:52,000 --> 00:02:50,030

over here there's less feedback as if it

64
00:02:53,770 --> 00:02:52,010
were a human being and you were doing a

65
00:02:56,050 --> 00:02:53,780
health check on it because really that's

66
00:02:57,790 --> 00:02:56,060
what our satellites allow us to do so

67
00:03:00,449 --> 00:02:57,800
we're gonna look at the vital signs of

68
00:03:03,190 --> 00:03:00,459
planet Earth here we go

69
00:03:05,020 --> 00:03:03,200
quick slide there's me these graphics

70
00:03:06,580 --> 00:03:05,030
are terrific they see the pulse is going

71
00:03:08,920 --> 00:03:06,590
Morris with us to get you in the mood

72
00:03:12,190 --> 00:03:08,930
for a medical examination of your home

73
00:03:14,620 --> 00:03:12,200
planet and off we go so here's what the

74
00:03:16,260 --> 00:03:14,630
planet looks like from space I'm hanging

75
00:03:20,140 --> 00:03:16,270
from the space station

76
00:03:22,090 --> 00:03:20,150
one-handed see how strong I am and from

77
00:03:25,540 --> 00:03:22,100
there you're going round the world at

78
00:03:27,100 --> 00:03:25,550
five miles per second same as most of

79
00:03:28,570 --> 00:03:27,110
the other low-earth orbiting satellites

80
00:03:29,920 --> 00:03:28,580
you're going around at five miles a

81
00:03:31,900 --> 00:03:29,930
second you're going around the world

82
00:03:32,140 --> 00:03:31,910
once every one and a half hours more or

83
00:03:34,900 --> 00:03:32,150
less

84
00:03:36,490 --> 00:03:34,910
ten times a day so you can imagine you

85
00:03:39,940 --> 00:03:36,500
could cover a lot of territory and you

86
00:03:43,509 --> 00:03:39,950
can see a lot of stuff all right so

87
00:03:46,090 --> 00:03:43,519
let's see what we can see the earth

88
00:03:47,949 --> 00:03:46,100

system is really pretty complicated this

89
00:03:50,259 --> 00:03:47,959
is based on data it's it's not just

90
00:03:51,759 --> 00:03:50,269
made-up cartoon but it's it's in this

91
00:03:53,470 --> 00:03:51,769
little magnetic bubble there's the

92
00:03:56,290 --> 00:03:53,480
magnetic field lines protected from

93
00:03:59,890 --> 00:03:56,300
particles streaming out from the Sun and

94
00:04:02,140 --> 00:03:59,900
there it is inside the magnetosphere as

95
00:04:04,420 --> 00:04:02,150
you come down further and further into

96
00:04:05,979 --> 00:04:04,430
the system you can start seeing the

97
00:04:08,680 --> 00:04:05,989
currents and this is given to us by

98
00:04:11,199 --> 00:04:08,690
satellites the currents of air moving

99
00:04:13,330 --> 00:04:11,209
around the planet these the fronts the

100
00:04:16,479 --> 00:04:13,340
hurricanes the depressions all those

101
00:04:19,090 --> 00:04:16,489
kinds of things the weather systems does

102
00:04:21,310 --> 00:04:19,100
it come down even deeper you could see

103
00:04:24,010 --> 00:04:21,320
how these air currents push the oceans

104
00:04:26,140 --> 00:04:24,020
along that and various other things that

105
00:04:28,360 --> 00:04:26,150
make the ocean so ocean circulation go

106
00:04:30,400 --> 00:04:28,370
and they are looking at the Gulf Stream

107
00:04:30,679 --> 00:04:30,410
coming up the east coast of the United

108
00:04:33,019 --> 00:04:30,689
States

109
00:04:35,570 --> 00:04:33,029
and now take a deep breath here we go

110
00:04:37,369 --> 00:04:35,580
underwater and all of this is based on

111
00:04:43,719 --> 00:04:37,379
data that we get from our satellite

112
00:04:45,769 --> 00:04:43,729
fleet in orbit oh no I shouldn't happen

113
00:04:50,479 --> 00:04:45,779

did you get us back on track

114
00:04:52,219 --> 00:04:50,489
terrific alright this is what you

115
00:04:55,299 --> 00:04:52,229
actually see with your eye particularly

116
00:04:58,309 --> 00:04:55,309
at night now what's the thing you notice

117
00:05:00,319 --> 00:04:58,319
they saw all the lights look at all the

118
00:05:03,049 --> 00:05:00,329
people millions and millions of people

119
00:05:06,139 --> 00:05:03,059
all doing stuff down there on earth all

120
00:05:08,899 --> 00:05:06,149
busy all using energy and doing

121
00:05:10,699 --> 00:05:08,909
productive and creative things so when

122
00:05:12,589 --> 00:05:10,709
you look at the world from space at

123
00:05:15,409 --> 00:05:12,599
night it kind of looks like that that's

124
00:05:16,909 --> 00:05:15,419
Italy and Excel the industrial regions

125
00:05:19,129 --> 00:05:16,919
all the places where the big cities are

126
00:05:22,249 --> 00:05:19,139
all the great cities lit up like

127
00:05:24,979 --> 00:05:22,259
Christmas trees just beautiful United

128
00:05:26,989 --> 00:05:24,989
States you can see the grid system of

129
00:05:28,459 --> 00:05:26,999
roads out in the middle of the country

130
00:05:30,379 --> 00:05:28,469
even where all the towns are spaced out

131
00:05:32,419 --> 00:05:30,389
on a grid system and look at the big

132
00:05:37,389 --> 00:05:32,429
East Coast conurbations you are a little

133
00:05:43,369 --> 00:05:39,829
how do we know all this how do we see

134
00:05:45,559 --> 00:05:43,379
all this we have 18 satellites 18

135
00:05:47,269 --> 00:05:45,569
satellites have long-term NASA that go

136
00:05:49,609 --> 00:05:47,279
around looking at all kinds of different

137
00:05:51,739 --> 00:05:49,619
things every day they look up rainfall

138
00:05:54,350 --> 00:05:51,749

snow well look at a few things that they

139
00:05:56,929 --> 00:05:54,360
can see some of them go around in orbits

140
00:05:58,339 --> 00:05:56,939
around the equator most of them go in

141
00:06:00,859 --> 00:05:58,349
orbits around the poles so they can

142
00:06:02,179 --> 00:06:00,869
cover the whole world every day and some

143
00:06:03,499 --> 00:06:02,189
of them you can see we call the a train

144
00:06:03,979 --> 00:06:03,509
coming down the left-hand side of the

145
00:06:06,169 --> 00:06:03,989
screen

146
00:06:08,479 --> 00:06:06,179
some of them follow each other along so

147
00:06:10,850 --> 00:06:08,489
we can compare observations from them

148
00:06:14,839 --> 00:06:10,860
and we actually correct each other using

149
00:06:16,369 --> 00:06:14,849
a you know simultaneous observations so

150
00:06:18,859 --> 00:06:16,379
here you are in space your earth this is

151
00:06:21,589 --> 00:06:18,869
a bit speeded up just to make you more

152
00:06:22,869 --> 00:06:21,599
exciting okay but here on space station

153
00:06:25,399 --> 00:06:22,879
looking through the forward window

154
00:06:26,869 --> 00:06:25,409
belting over the planet and I'm going to

155
00:06:29,689 --> 00:06:26,879
show you some of the observations that

156
00:06:33,870 --> 00:06:29,699
we've been able to make only over the

157
00:06:35,820 --> 00:06:33,880
last 20 years since we've satellite

158
00:06:37,290 --> 00:06:35,830
first of all installation that's the

159
00:06:40,170 --> 00:06:37,300
amount of sunlight hitting the world

160
00:06:43,220 --> 00:06:40,180
from outer space outgoing radiation is

161
00:06:46,230 --> 00:06:43,230
the stuff that's being lost for space

162
00:06:49,890 --> 00:06:46,240
precipitation subsurface water

163
00:06:51,690 --> 00:06:49,900

I can see leaf area we could see their

164
00:06:54,240 --> 00:06:51,700
number the amount of green leaves on the

165
00:06:56,460 --> 00:06:54,250
planet and also the amount of tied in

166
00:06:58,590 --> 00:06:56,470
the atmosphere these are observations we

167
00:07:01,800 --> 00:06:58,600
make through space all that every day

168
00:07:03,930 --> 00:07:01,810
everywhere the wind missions the

169
00:07:05,550 --> 00:07:03,940
saltiness of the oceans is kind of a

170
00:07:07,380 --> 00:07:05,560
miracle to me that we can measure the

171
00:07:11,070 --> 00:07:07,390
saltiness of the surface ocean from

172
00:07:13,440 --> 00:07:11,080
space no means how bright the surface is

173
00:07:16,680 --> 00:07:13,450
how reflective it is land temperature

174
00:07:18,390 --> 00:07:16,690
its hotness like various gases like

175
00:07:22,380 --> 00:07:18,400
carbon dioxide nitrogen dioxide those

176
00:07:24,480 --> 00:07:22,390
are pollutants and lost wall gravity

177
00:07:25,920 --> 00:07:24,490
disturbances in the gravity field and

178
00:07:27,750 --> 00:07:25,930
snow and ice and I'll come back to that

179
00:07:30,300 --> 00:07:27,760
later so we're looking at the world in

180
00:07:32,280 --> 00:07:30,310
all kinds of different ways and getting

181
00:07:36,720 --> 00:07:32,290
all these different kinds of data all

182
00:07:37,980 --> 00:07:36,730
the time so I can't talk about orbit

183
00:07:40,230 --> 00:07:37,990
today so I'm just going to talk about

184
00:07:45,240 --> 00:07:40,240
three things I'm talk about the water

185
00:07:47,040 --> 00:07:45,250
cycle as the oceans I'm going to talk

186
00:07:48,750 --> 00:07:47,050
about the land biosphere or the living

187
00:07:51,960 --> 00:07:48,760
things on the land that we can see from

188
00:07:53,550 --> 00:07:51,970

space and last of all I'm going to talk

189
00:07:54,840 --> 00:07:53,560
about what scientists call the

190
00:07:57,480 --> 00:07:54,850
cryosphere but the people that you and

191
00:07:59,400 --> 00:07:57,490
me is is ice and snow ice and snow

192
00:08:01,680 --> 00:07:59,410
everywhere around the world ok so we're

193
00:08:05,100 --> 00:08:01,690
going to get cracking with the water

194
00:08:07,620 --> 00:08:05,110
cycle so you take all the data from

195
00:08:09,990 --> 00:08:07,630
satellites can see and you put it

196
00:08:12,510 --> 00:08:10,000
through a computer and this is the flow

197
00:08:13,980 --> 00:08:12,520
of atmospheric water vapor around the

198
00:08:16,080 --> 00:08:13,990
world you can see it kind of bubbles out

199
00:08:21,080 --> 00:08:16,090
of the equator it gets transported

200
00:08:26,850 --> 00:08:24,330
here's the surface oceans this is the

201
00:08:29,070 --> 00:08:26,860
temperature of the surface oceans as

202
00:08:30,960 --> 00:08:29,080
measured from space so you can see how

203
00:08:33,330 --> 00:08:30,970
much warmer the Equator is than the

204
00:08:34,890 --> 00:08:33,340
poles that's kind of obvious right where

205
00:08:36,810 --> 00:08:34,900
it's icy it's cold and in the middle of

206
00:08:39,540 --> 00:08:36,820
the world it's warm but look at the

207
00:08:41,339 --> 00:08:39,550
middle coming off South America going

208
00:08:43,530 --> 00:08:41,349
across the Pacific you can see these

209
00:08:44,740 --> 00:08:43,540
kind of big waves moving across the

210
00:08:46,260 --> 00:08:44,750
Pacific

211
00:08:48,490 --> 00:08:46,270
that's due to planetary scale

212
00:08:50,770 --> 00:08:48,500
disturbances in the surface of the ocean

213
00:08:53,680 --> 00:08:50,780

and that controls whether actually all

214
00:08:55,000 --> 00:08:53,690
over the Americas El Ninos and la niñas

215
00:08:57,460 --> 00:08:55,010
you've probably heard of those

216
00:09:02,190 --> 00:08:57,470
so that's surface temperature how warm

217
00:09:04,510 --> 00:09:02,200
the ocean is this is salinity of

218
00:09:07,870 --> 00:09:04,520
saltiness of a surface ocean and we've

219
00:09:10,330 --> 00:09:07,880
only been able to do this since 2012

220
00:09:11,560 --> 00:09:10,340
this is a brand-new measurement before

221
00:09:13,330 --> 00:09:11,570
then the only thing we knew about

222
00:09:15,520 --> 00:09:13,340
saltiness of the ocean was when people

223
00:09:17,680 --> 00:09:15,530
stuck a bucket in the water and measure

224
00:09:19,030 --> 00:09:17,690
the saltiness on a ship so now we can

225
00:09:20,530 --> 00:09:19,040
see it all over the place

226
00:09:22,030 --> 00:09:20,540
and if you look carefully you can see

227
00:09:24,460 --> 00:09:22,040
some really interesting things look at

228
00:09:25,990 --> 00:09:24,470
the Amazon where the Amazon comes out in

229
00:09:29,950 --> 00:09:26,000
the Atlantic you can see a kind of blue

230
00:09:31,750 --> 00:09:29,960
tongue of freshwater coming out you can

231
00:09:34,390 --> 00:09:31,760
see that the Atlantic is a lot saltier

232
00:09:36,010 --> 00:09:34,400
than the Pacific and that's because it

233
00:09:38,410 --> 00:09:36,020
rains harder in the Pacific there's more

234
00:09:40,990 --> 00:09:38,420
freshwater on the surface and you can

235
00:09:45,040 --> 00:09:41,000
see lots of freshwater up where the ice

236
00:09:47,980 --> 00:09:45,050
melts in the summer in the northern ice

237
00:09:50,290 --> 00:09:47,990
cap and down by Antarctica so very

238
00:09:53,050 --> 00:09:50,300

interesting patterns in salinity that we

239
00:09:55,690 --> 00:09:53,060
could never observe a form now salt in

240
00:09:58,150 --> 00:09:55,700
water makes it heavy okay it's a little

241
00:10:00,130 --> 00:09:58,160
bit heavier than freshwater that's why

242
00:10:02,770 --> 00:10:00,140
you floats so well in the Dead Sea the

243
00:10:04,900 --> 00:10:02,780
Mediterranean and also hot water is

244
00:10:06,520 --> 00:10:04,910
lighter than cold water and knowing

245
00:10:10,480 --> 00:10:06,530
these two things how hot the water is

246
00:10:12,730 --> 00:10:10,490
and how salty it is allows you to make a

247
00:10:15,970 --> 00:10:12,740
predictive model of the ocean

248
00:10:17,850 --> 00:10:15,980
circulation so a computer here is

249
00:10:21,070 --> 00:10:17,860
simulating based on those observations

250
00:10:23,380 --> 00:10:21,080
where all the water is going and how its

251
00:10:24,550 --> 00:10:23,390
flowing and we've known this for years

252
00:10:27,520 --> 00:10:24,560
but now we know it in great detail

253
00:10:29,740 --> 00:10:27,530
there's a huge conveyor belt of water

254
00:10:31,690 --> 00:10:29,750
around the planet this water goes round

255
00:10:33,250 --> 00:10:31,700
and round and Arctica and spins off

256
00:10:35,950 --> 00:10:33,260
these loops that go up into the great

257
00:10:38,410 --> 00:10:35,960
ocean basis it goes out pretty quickly

258
00:10:40,600 --> 00:10:38,420
towards the North Pole and then sinks

259
00:10:47,079 --> 00:10:40,610
and comes back very slowly across the

260
00:10:52,910 --> 00:10:49,699
in the atmosphere of water vapor moves

261
00:10:54,620 --> 00:10:52,920
around as clouds or just like steam it

262
00:10:57,380 --> 00:10:54,630
looks like steam water vapor coming out

263
00:11:00,319 --> 00:10:57,390

of your kettle and here the observations

264
00:11:01,910 --> 00:11:00,329
from space again put into a computer we

265
00:11:03,259 --> 00:11:01,920
can find out how much water is moving

266
00:11:05,660 --> 00:11:03,269
through the atmosphere and where it's

267
00:11:07,850 --> 00:11:05,670
going a lot of it gets moved around by

268
00:11:09,889 --> 00:11:07,860
storms as you would imagine that

269
00:11:12,860 --> 00:11:09,899
hurricanes move a lot of a water vapor

270
00:11:14,810 --> 00:11:12,870
away from the equator towards the higher

271
00:11:20,319 --> 00:11:14,820
latitudes where they break up and then

272
00:11:23,930 --> 00:11:21,530
okay

273
00:11:26,030 --> 00:11:23,940
the latest thing in the satellite fleet

274
00:11:30,500 --> 00:11:26,040
that we just launched about a year ago

275
00:11:32,180 --> 00:11:30,510
was the global precipitation mission so

276
00:11:33,470 --> 00:11:32,190
it's a big machine it was built up at

277
00:11:35,000 --> 00:11:33,480
Goddard but you've just down the road

278
00:11:37,310 --> 00:11:35,010
from here it's about the size of a

279
00:11:39,290 --> 00:11:37,320
school bus and it has a radar that can

280
00:11:41,180 --> 00:11:39,300
see inside clouds who see the rain as

281
00:11:43,730 --> 00:11:41,190
it's falling as where there's a

282
00:11:48,110 --> 00:11:43,740
Radiometer that maps the precipitation

283
00:11:50,150 --> 00:11:48,120
over wide areas so this thing scoots

284
00:11:50,829 --> 00:11:50,160
around the world ten times today here it

285
00:11:53,990 --> 00:11:50,839
comes

286
00:11:55,430 --> 00:11:54,000
and it kind of vacuum cleans its way

287
00:11:57,800 --> 00:11:55,440
around the world leaving a little stripe

288
00:11:59,960 --> 00:11:57,810

of data and taking these measurements

289
00:12:03,019 --> 00:11:59,970
and showing us what it's got but it's

290
00:12:04,730 --> 00:12:03,029
not alone there eight other satellites

291
00:12:06,889 --> 00:12:04,740
that belong to some for the US but

292
00:12:10,370 --> 00:12:06,899
mostly to other countries Japan France

293
00:12:12,650 --> 00:12:10,380
Europe Korea and we all combined our

294
00:12:14,810 --> 00:12:12,660
data to get an idea of precipitation

295
00:12:16,850 --> 00:12:14,820
around the world all the time every

296
00:12:21,130 --> 00:12:16,860
three hours in fact our satellites going

297
00:12:25,630 --> 00:12:24,220
so one really spectacular example of the

298
00:12:26,470 --> 00:12:25,640
observation that you can get from these

299
00:12:29,860 --> 00:12:26,480
new satellites

300
00:12:32,550 --> 00:12:29,870
here's GPM shooting over the United

301
00:12:35,980 --> 00:12:32,560
States during the March snow storm and

302
00:12:39,190 --> 00:12:35,990
you can see the warm colors are rain but

303
00:12:41,410 --> 00:12:39,200
the blue color are snow so the first

304
00:12:44,019 --> 00:12:41,420
time we can actually see snow falling in

305
00:12:47,019 --> 00:12:44,029
the clouds then turning into rain is it

306
00:12:47,610 --> 00:12:47,029
gets low atmosphere then falling on the

307
00:12:51,540 --> 00:12:47,620
ground

308
00:12:56,070 --> 00:12:54,240
this is that's kind of

309
00:12:57,650 --> 00:12:56,080
blue puddles that snow that's actually

310
00:13:00,630 --> 00:12:57,660
accumulated on the ground

311
00:13:01,740 --> 00:13:00,640
the stuff falling and we're seeing it

312
00:13:07,020 --> 00:13:01,750
accumulate on the ground

313
00:13:11,490 --> 00:13:09,900

so all of the stuff is useful we need to

314
00:13:12,930 --> 00:13:11,500
know about precipitation we need to know

315
00:13:14,940 --> 00:13:12,940
about the water cycle why is it

316
00:13:17,130 --> 00:13:14,950
important well no one likes to be

317
00:13:19,110 --> 00:13:17,140
flooded no one likes to be in a drought

318
00:13:21,870 --> 00:13:19,120
and no one likes to have a landslides

319
00:13:24,090 --> 00:13:21,880
fall on top of them so we can't stop

320
00:13:25,860 --> 00:13:24,100
those things from space but we can tell

321
00:13:27,930 --> 00:13:25,870
you if they're going to happen and we

322
00:13:30,870 --> 00:13:27,940
can keep an eye on them as they develop

323
00:13:32,070 --> 00:13:30,880
so for morning is this vital and I think

324
00:13:34,740 --> 00:13:32,080
any of you've known who've lived down in

325
00:13:36,900 --> 00:13:34,750
the Gulf states like I have down there

326
00:13:38,820 --> 00:13:36,910
in Texas having a three-day warning for

327
00:13:40,890 --> 00:13:38,830
a hurricane is really good it allows you

328
00:13:46,020 --> 00:13:40,900
to get the dog and the cat in the boxes

329
00:13:47,190 --> 00:13:46,030
and out to somewhere safe all right next

330
00:13:50,460 --> 00:13:47,200
we're going to talk about the land

331
00:13:53,010 --> 00:13:50,470
biosphere for about 30 years now we've

332
00:13:55,680 --> 00:13:53,020
had satellites that can see greenness

333
00:13:58,170 --> 00:13:55,690
green vegetation and this is a

334
00:14:00,750 --> 00:13:58,180
speeded-up movie showing not only the

335
00:14:03,780 --> 00:14:00,760
vegetation on land but also the plankton

336
00:14:05,700 --> 00:14:03,790
in the world's oceans so you can see as

337
00:14:08,340 --> 00:14:05,710
the seasons change you've got this green

338
00:14:11,130 --> 00:14:08,350

wave that moves up and down the the

339
00:14:12,720 --> 00:14:11,140
planet so every summer you have this

340
00:14:14,400 --> 00:14:12,730
wave of greenness goes all the way up

341
00:14:20,330 --> 00:14:14,410
through North America and then the

342
00:14:25,310 --> 00:14:21,860
and here we are we spread it all out

343
00:14:27,830 --> 00:14:25,320
we've calculated how much production how

344
00:14:29,900 --> 00:14:27,840
much growth there is based on these

345
00:14:33,710 --> 00:14:29,910
measurements so here you are you're

346
00:14:36,470 --> 00:14:33,720
looking at how much wood or tissue work

347
00:14:40,100 --> 00:14:36,480
or any bits of plant are being made

348
00:14:42,260 --> 00:14:40,110
every time a green leaf fixes sunlight

349
00:14:43,760 --> 00:14:42,270
and does photosynthesis so you're

350
00:14:45,470 --> 00:14:43,770
actually looking at the heartbeat of the

351
00:14:48,050 --> 00:14:45,480
planet here every year

352
00:14:50,360 --> 00:14:48,060
it sucks down carbon dioxide into green

353
00:14:52,720 --> 00:14:50,370
living things and every winter it throws

354
00:14:55,700 --> 00:14:52,730
it back out again

355
00:14:57,860 --> 00:14:55,710
one of the ways that all this growth

356
00:15:00,620 --> 00:14:57,870
gets back into the internet into the

357
00:15:04,460 --> 00:15:00,630
atmosphere is of course through burning

358
00:15:05,840 --> 00:15:04,470
forests volcanoes but a lot of carbon

359
00:15:09,440 --> 00:15:05,850
dioxide that gets into the atmosphere

360
00:15:14,840 --> 00:15:09,450
comes from power production and us

361
00:15:19,480 --> 00:15:14,850
driving around in cars look slinger your

362
00:15:27,100 --> 00:15:23,949
I can't go forward on this nevermind

363
00:15:30,280 --> 00:15:27,110

okay so overtime because we've been

364
00:15:32,920 --> 00:15:30,290
burning fossil fuels and running around

365
00:15:34,570 --> 00:15:32,930
the cars and things the amount of carbon

366
00:15:36,220 --> 00:15:34,580
dioxide has accumulated in the

367
00:15:37,990 --> 00:15:36,230
atmosphere but it doesn't go up

368
00:15:41,110 --> 00:15:38,000
Stephanie if you look every year it goes

369
00:15:43,210 --> 00:15:41,120
up and down in a kind of cycle and

370
00:15:45,460 --> 00:15:43,220
that's because every summer all the

371
00:15:48,730 --> 00:15:45,470
green forests in the northern hemisphere

372
00:15:50,440 --> 00:15:48,740
suck down carbon dioxide so it goes down

373
00:15:52,870 --> 00:15:50,450
a bit and in the winter it comes back

374
00:15:54,639 --> 00:15:52,880
out again so you see this annual cycle

375
00:15:56,139 --> 00:15:54,649
and of course every year we're adding a

376
00:15:58,389 --> 00:15:56,149
little bit more carbon dioxide through

377
00:16:01,210 --> 00:15:58,399
fossil fuel burning so the trend is

378
00:16:04,120 --> 00:16:01,220
overall upwards now the changing colors

379
00:16:06,519 --> 00:16:04,130
you can see their observations of carbon

380
00:16:09,130 --> 00:16:06,529
dioxide from satellite and you'll notice

381
00:16:10,600 --> 00:16:09,140
that more carbon dioxide is produced in

382
00:16:12,430 --> 00:16:10,610
the northern hemisphere through the

383
00:16:15,160 --> 00:16:12,440
southern hemisphere and that's because

384
00:16:16,300 --> 00:16:15,170
most of us live there most of us live in

385
00:16:18,310 --> 00:16:16,310
the northern hemisphere that's where the

386
00:16:20,320 --> 00:16:18,320
industry is that's where all our cars

387
00:16:22,480 --> 00:16:20,330
are driving around so that's where most

388
00:16:26,820 --> 00:16:22,490

of the carbon dioxide gets released and

389
00:16:31,110 --> 00:16:28,889
okay so we could put these two bits of

390
00:16:33,720 --> 00:16:31,120
information together the kind of yellow

391
00:16:35,460 --> 00:16:33,730
smokey stuff is a satellite observation

392
00:16:38,910 --> 00:16:35,470
of carbon dioxide and the green on the

393
00:16:41,250 --> 00:16:38,920
surface is vegetation and you can see

394
00:16:43,980 --> 00:16:41,260
how there's sort of a correlation

395
00:16:45,360 --> 00:16:43,990
between the two now when it starts to

396
00:16:47,340 --> 00:16:45,370
green up in the northern hemisphere it

397
00:16:49,829 --> 00:16:47,350
sucks down the carbon dioxide into the

398
00:16:52,190 --> 00:16:49,839
trees and in the winter when it all dies

399
00:16:54,930 --> 00:16:52,200
the carbon dioxide comes back out again

400
00:16:57,300 --> 00:16:54,940
so two different satellites are telling

401
00:16:59,610 --> 00:16:57,310
us where the carbon dioxide is going a

402
00:17:01,560 --> 00:16:59,620
lot of it gets sucked into the trees and

403
00:17:06,350 --> 00:17:01,570
about the same amount actually gets into

404
00:17:10,280 --> 00:17:09,770
fires as one-way carbon dioxide gets

405
00:17:12,200 --> 00:17:10,290
back

406
00:17:14,330 --> 00:17:12,210
that's how dead vegetation very quickly

407
00:17:16,730 --> 00:17:14,340
sends stuff back into the atmosphere and

408
00:17:20,420 --> 00:17:16,740
this is a satellite picture showing you

409
00:17:23,840 --> 00:17:20,430
all the fires in Africa as observed from

410
00:17:26,030 --> 00:17:23,850
space changing over the year what's

411
00:17:28,280 --> 00:17:26,040
happening here on sheet is people they

412
00:17:29,750 --> 00:17:28,290
grow their crops and at the end of the

413
00:17:32,660 --> 00:17:29,760

season you've got all this dry stubble

414
00:17:34,490 --> 00:17:32,670
dry trash they just burn it right

415
00:17:36,680 --> 00:17:34,500
so there's fertilize in the fields for

416
00:17:38,000 --> 00:17:36,690
the next year so this has been going on

417
00:17:40,280 --> 00:17:38,010
for thousands of years this is how

418
00:17:45,710 --> 00:17:40,290
people make a living so you can actually

419
00:17:49,460 --> 00:17:45,720
see it from space so someone down there

420
00:17:51,140 --> 00:17:49,470
is working hard other things we can see

421
00:17:53,690 --> 00:17:51,150
from space here's Las Vegas anybody here

422
00:17:56,690 --> 00:17:53,700
from Las Vegas yay well it's got bigger

423
00:17:58,850 --> 00:17:56,700
look at all those golf courses all those

424
00:18:00,620 --> 00:17:58,860
like new houses and things and this Las

425
00:18:03,170 --> 00:18:00,630
Vegas has got bigger over the years this

426
00:18:06,980 --> 00:18:03,180
is Landsat data you can see that Fortin

427
00:18:11,570 --> 00:18:06,990
Lake Mead it's got smaller there's been

428
00:18:13,460 --> 00:18:11,580
some dry years and that combined with

429
00:18:15,610 --> 00:18:13,470
increased demand has has slowed down the

430
00:18:17,720 --> 00:18:15,620
lake a little bit you probably know that

431
00:18:19,670 --> 00:18:17,730
the lowest has ever been right now

432
00:18:22,340 --> 00:18:19,680
that's right big city about twice as big

433
00:18:26,390 --> 00:18:22,350
as it was so we've been used to looking

434
00:18:28,910 --> 00:18:26,400
at this for the last 30 years other

435
00:18:31,070 --> 00:18:28,920
things we can see from space all kinds

436
00:18:32,930 --> 00:18:31,080
of stuff here's some mining activity in

437
00:18:35,270 --> 00:18:32,940
West Virginia where they cut off the top

438
00:18:37,220 --> 00:18:35,280

of the mountain together the call and as

439
00:18:42,180 --> 00:18:37,230
they move out is slowly grows back we've

440
00:18:47,690 --> 00:18:44,369
all kinds of different things here Saudi

441
00:18:50,490 --> 00:18:47,700
Arabia and what you're seeing is people

442
00:18:52,919 --> 00:18:50,500
drilling for water and then starting

443
00:18:55,710 --> 00:18:52,929
irrigation and growing vegetables in the

444
00:18:58,019 --> 00:18:55,720
middle of the desert so incredible

445
00:19:00,659 --> 00:18:58,029
amount of effort to grow food for local

446
00:19:02,009 --> 00:19:00,669
markets out there in Saudi Arabia and

447
00:19:04,499 --> 00:19:02,019
this is true across the whole Middle

448
00:19:07,019 --> 00:19:04,509
East if you've got enough energy to get

449
00:19:13,889 --> 00:19:07,029
the water out from very deep levels you

450
00:19:16,379 --> 00:19:13,899
can have yourself a lettuce all right so

451
00:19:18,480 --> 00:19:16,389
I've been talking about carbon dioxide

452
00:19:19,799 --> 00:19:18,490
of the atmosphere and that's helps to

453
00:19:22,110 --> 00:19:19,809
increase the temperature of the

454
00:19:24,659 --> 00:19:22,120
atmosphere and since we've been watching

455
00:19:26,100 --> 00:19:24,669
since 1890 and making careful

456
00:19:28,110 --> 00:19:26,110
measurements of atmospheric temperature

457
00:19:29,399 --> 00:19:28,120
the world has got warmer and I want you

458
00:19:30,930 --> 00:19:29,409
to look at this picture very carefully

459
00:19:32,970 --> 00:19:30,940
and see if you could tell me two things

460
00:19:36,779 --> 00:19:32,980
about what's going on so I come into the

461
00:19:39,419 --> 00:19:36,789
90s the world's getting warmer and there

462
00:19:44,020 --> 00:19:39,429
we stopped at 2013 so what two things

463
00:19:49,270 --> 00:19:46,150

it's got warmer everywhere but where

464
00:19:53,080 --> 00:19:49,280
does he got warmer most quickly North

465
00:19:55,030 --> 00:19:53,090
Pole it's twice as warm two and a half

466
00:19:58,090 --> 00:19:55,040
times warmer at the war at the North

467
00:20:00,250 --> 00:19:58,100
Pole then of the planetary average now

468
00:20:02,920 --> 00:20:00,260
why is that exactly there's a very good

469
00:20:11,410 --> 00:20:02,930
reason well get to it I'm gonna tell you

470
00:20:16,060 --> 00:20:11,420
so I bet you know the answer but I'll

471
00:20:19,120 --> 00:20:16,070
show you okay it's it's so warming up at

472
00:20:22,210 --> 00:20:19,130
the North Pole because the ice has been

473
00:20:23,290 --> 00:20:22,220
decreasing over the last century as far

474
00:20:27,040 --> 00:20:23,300
as we could tell we've only been

475
00:20:28,780 --> 00:20:27,050
watching it from space since 1979 but

476
00:20:31,600 --> 00:20:28,790
the amount of Arctic sea ice is

477
00:20:34,390 --> 00:20:31,610
decreasing and what happens when you

478
00:20:37,450 --> 00:20:34,400
melt nice white bright ice that reflects

479
00:20:39,790 --> 00:20:37,460
sunlight you expose pretty much black

480
00:20:41,440 --> 00:20:39,800
water and that absorbs sunlight warms up

481
00:20:44,710 --> 00:20:41,450
a bit more and nibbles away at another

482
00:20:46,000 --> 00:20:44,720
bit of ice so it's a runaway feedback as

483
00:20:48,190 --> 00:20:46,010
the water gets warm it melts more ice

484
00:20:51,310 --> 00:20:48,200
which was more water which melts more

485
00:20:55,660 --> 00:20:51,320
ice so it accelerates and you can see

486
00:20:58,000 --> 00:20:55,670
how over the last decade or so there's

487
00:21:00,130 --> 00:20:58,010
been a real downturn in Arctic sea ice

488
00:21:02,130 --> 00:21:00,140

and our models predict if this keeps

489
00:21:05,410 --> 00:21:02,140
going you'll be able to get in a kayak

490
00:21:07,960 --> 00:21:05,420
sometime maybe in the 20 60 s or 20 70 s

491
00:21:09,550 --> 00:21:07,970
and kayak right over the North Pole in

492
00:21:11,590 --> 00:21:09,560
the middle of summer there won't be any

493
00:21:13,360 --> 00:21:11,600
ice you'll be able to go right over the

494
00:21:15,340 --> 00:21:13,370
top it'll freeze up again in the winter

495
00:21:19,540 --> 00:21:15,350
when it gets real cold but you'll have

496
00:21:22,330 --> 00:21:19,550
an ice-free Polar ocean at the end of

497
00:21:23,620 --> 00:21:22,340
summer so these are all satellite

498
00:21:25,720 --> 00:21:23,630
observations we have a satellite that

499
00:21:28,690 --> 00:21:25,730
could see through clouds and can measure

500
00:21:33,440 --> 00:21:28,700
the amount of ice area very well it's

501
00:21:39,169 --> 00:21:36,169
and this is the observation turned into

502
00:21:41,149 --> 00:21:39,179
a kind of a movie and you can see ice

503
00:21:43,339 --> 00:21:41,159
isn't this sort of static boring stuff

504
00:21:45,169 --> 00:21:43,349
it moves around depending on the winds

505
00:21:48,469 --> 00:21:45,179
and the currents it's kind of a life

506
00:21:51,859 --> 00:21:48,479
here it is his winter ice up and the ice

507
00:21:55,069 --> 00:21:51,869
slides down around Greenland and Iceland

508
00:21:57,379 --> 00:21:55,079
and kind of like custard moves around

509
00:21:59,239 --> 00:21:57,389
all over the place but the retreats in

510
00:22:05,560 --> 00:21:59,249
the summer but the winds and the

511
00:22:10,780 --> 00:22:09,070
and here's the winds and you can see how

512
00:22:14,670 --> 00:22:10,790
the wind field tends to push the ice

513
00:22:17,530 --> 00:22:14,680

over on top of Greenland and Canada

514
00:22:20,920 --> 00:22:17,540
preferentially and away from Alaska and

515
00:22:23,260 --> 00:22:20,930
the Russian North Russian coast which is

516
00:22:28,590 --> 00:22:23,270
why the ice extent is disappearing there

517
00:22:33,149 --> 00:22:31,620
okay now there's another interesting

518
00:22:35,610 --> 00:22:33,159
thing is that the sea ice around

519
00:22:37,560 --> 00:22:35,620
Antarctica is about the same it's not

520
00:22:39,690 --> 00:22:37,570
really changing much or maybe even

521
00:22:43,830 --> 00:22:39,700
growing a tiny little bit whereas an

522
00:22:46,590 --> 00:22:43,840
Arctic it's decreasing a lot why is that

523
00:22:50,190 --> 00:22:46,600
well Antarctica is a continent

524
00:22:52,680 --> 00:22:50,200
surrounded by an ocean whereas the North

525
00:22:55,409 --> 00:22:52,690
Pole is an ocean surrounded by

526
00:22:57,330 --> 00:22:55,419
continents completely different systems

527
00:22:59,039 --> 00:22:57,340
in Antarctica there's a kind of a wind

528
00:23:01,379 --> 00:22:59,049
field that goes around there and it

529
00:23:04,070 --> 00:23:01,389
helps keep the cold in but even now

530
00:23:08,669 --> 00:23:04,080
we're seeing decreasing ice on top of

531
00:23:10,619 --> 00:23:08,679
the continent top Antarctica one of the

532
00:23:12,629 --> 00:23:10,629
ways we do that is to find out where the

533
00:23:13,310 --> 00:23:12,639
ice is going is to use a radar from

534
00:23:15,659 --> 00:23:13,320
space

535
00:23:18,299 --> 00:23:15,669
Tuukka see how fast the ice is moving

536
00:23:20,580 --> 00:23:18,309
and this is speed it up okay obviously

537
00:23:23,009 --> 00:23:20,590
but you can see how the ice collects

538
00:23:27,860 --> 00:23:23,019

into glaciers and then drops into the

539
00:23:32,360 --> 00:23:30,010
first of all I thought this was lemmings

540
00:23:40,280 --> 00:23:32,370
but no it's not this is actually ice

541
00:23:45,380 --> 00:23:42,470
now what's happening in Antarctica and

542
00:23:46,970 --> 00:23:45,390
Greenland is a process that's very

543
00:23:49,550 --> 00:23:46,980
simple but people hadn't thought of it

544
00:23:51,530 --> 00:23:49,560
before when the ice starts melting some

545
00:23:52,820 --> 00:23:51,540
of the water wiggles this way down to

546
00:23:55,580 --> 00:23:52,830
the cracks in the ice and it gets

547
00:23:58,580 --> 00:23:55,590
between the rock and the ice and that

548
00:24:01,250 --> 00:23:58,590
works like you know like butter and the

549
00:24:04,610 --> 00:24:01,260
ice can slide off more easily into the

550
00:24:06,560 --> 00:24:04,620
into the ocean and on Greenland we've

551
00:24:09,620 --> 00:24:06,570
seen the speed of the glaciers and

552
00:24:11,090 --> 00:24:09,630
double quite recently over the last 20

553
00:24:12,680 --> 00:24:11,100
years so the accelerate you know they

554
00:24:14,690 --> 00:24:12,690
call it the galloping glaciers these

555
00:24:16,160 --> 00:24:14,700
guys are speeding up and falling into

556
00:24:21,350 --> 00:24:16,170
the ocean much quicker than they used to

557
00:24:23,840 --> 00:24:21,360
and there's a magical way we can see

558
00:24:25,970 --> 00:24:23,850
this at work we have two satellites that

559
00:24:27,650 --> 00:24:25,980
chase each other around the world and

560
00:24:29,840 --> 00:24:27,660
when the lead one goes over something

561
00:24:31,910 --> 00:24:29,850
heavy it drops down a little bit and the

562
00:24:34,310 --> 00:24:31,920
trailing one measures its distance using

563
00:24:36,530 --> 00:24:34,320

radio you can see how fast it's gone

564
00:24:38,810 --> 00:24:36,540
down and the reverse when the trailing

565
00:24:40,780 --> 00:24:38,820
one goes over something heavy so you can

566
00:24:42,520 --> 00:24:40,790
keep track of the different amounts of

567
00:24:46,220 --> 00:24:42,530
material that's on the Earth's surface

568
00:24:48,890 --> 00:24:46,230
using the systems called grace and

569
00:24:51,410 --> 00:24:48,900
basically you can weigh the amount of

570
00:24:54,740 --> 00:24:51,420
ice on Greenland using this technique

571
00:24:57,530 --> 00:24:54,750
you can figure out how much the mass of

572
00:25:00,380 --> 00:24:57,540
ice is stacked up on Greenland and here

573
00:25:02,420 --> 00:25:00,390
you are from since 2003 2010 that's the

574
00:25:04,610 --> 00:25:02,430
only record we have since we invented

575
00:25:07,100 --> 00:25:04,620
this thing and you can see that the ice

576
00:25:09,290 --> 00:25:07,110
goes down every summer as it melts or

577
00:25:11,270 --> 00:25:09,300
recovers a bit in winter as it snows it

578
00:25:15,260 --> 00:25:11,280
goes down again in the next summer but

579
00:25:18,830 --> 00:25:15,270
overall were losing ice and very fast at

580
00:25:21,890 --> 00:25:18,840
the rate of about 200 or 300 Giga tons a

581
00:25:25,250 --> 00:25:21,900
year now a Giga ton is a cube of ice

582
00:25:27,050 --> 00:25:25,260
that's half a mile on a side it's out a

583
00:25:30,560 --> 00:25:27,060
big cube of ice okay it's actually a

584
00:25:32,480 --> 00:25:30,570
kilometer on a side so 200 to 300 Giga

585
00:25:34,730 --> 00:25:32,490
tons of ice every year falling off

586
00:25:40,340 --> 00:25:34,740
Greenland into the ocean are not being

587
00:25:45,800 --> 00:25:42,540
and we've had a satellite that's been

588
00:25:48,630 --> 00:25:45,810

was observing the height of the ice

589
00:25:51,810 --> 00:25:48,640
early on in this decade they'd only last

590
00:25:54,480 --> 00:25:51,820
about three years so after that we had a

591
00:25:56,370 --> 00:25:54,490
fill-in using aircraft and here's

592
00:25:58,020 --> 00:25:56,380
aircraft bravely struggling through the

593
00:26:01,200 --> 00:25:58,030
polar ice clouds to measure of the ice

594
00:26:02,790 --> 00:26:01,210
over Antarctica it's a lot of fun by the

595
00:26:04,500 --> 00:26:02,800
way you know stand up there in a window

596
00:26:07,140 --> 00:26:04,510
and look out the ice gets go blazing by

597
00:26:08,190 --> 00:26:07,150
quite beautiful but but there's a whole

598
00:26:09,720 --> 00:26:08,200
lot of instruments here that are

599
00:26:13,380 --> 00:26:09,730
measuring the amount of snow and ice

600
00:26:14,850 --> 00:26:13,390
that's stacked up this is Antarctica all

601
00:26:19,050 --> 00:26:14,860
the mountains down there really

602
00:26:21,260 --> 00:26:19,060
beautiful and you're nice and warm in

603
00:26:24,780 --> 00:26:21,270
you don't have to tough it out there

604
00:26:26,100 --> 00:26:24,790
like a monster mascot or anything so

605
00:26:27,540 --> 00:26:26,110
we're using aircraft now because we

606
00:26:34,110 --> 00:26:27,550
don't have a satellite to measure the

607
00:26:35,940 --> 00:26:34,120
ice depth but very soon in 2017 we hope

608
00:26:37,950 --> 00:26:35,950
we'll be launching a satellite that's

609
00:26:41,610 --> 00:26:37,960
going to use lasers to determine the

610
00:26:43,290 --> 00:26:41,620
exact height of the ice pack and this

611
00:26:45,090 --> 00:26:43,300
will tell us how quickly the ice is

612
00:26:47,130 --> 00:26:45,100
going down it also tell us how much ice

613
00:26:49,290 --> 00:26:47,140

there is in the oceans and it'll tell us

614
00:26:51,540 --> 00:26:49,300
how quickly the ice is moving off the

615
00:26:52,590 --> 00:26:51,550
continents into the ocean so that's

616
00:26:54,240 --> 00:26:52,600
something to look forward to

617
00:27:00,150 --> 00:26:54,250
we've been working on that and Goddard

618
00:27:03,390 --> 00:27:01,410
we have many different ways of

619
00:27:06,030 --> 00:27:03,400
estimating the amount of ice it's and

620
00:27:07,620 --> 00:27:06,040
they sort of agree the completely

621
00:27:09,540 --> 00:27:07,630
independent methods they sort of agree

622
00:27:12,390 --> 00:27:09,550
and they're showing God on average were

623
00:27:15,270 --> 00:27:12,400
losing about two hundred and fifty Giga

624
00:27:19,220 --> 00:27:15,280
tons of ice off the landmass into the

625
00:27:21,750 --> 00:27:19,230
oceans every year so where does it go

626
00:27:24,900 --> 00:27:21,760
well a couple things are going on the

627
00:27:27,030 --> 00:27:24,910
oceans getting warmer a bit warmer every

628
00:27:28,740 --> 00:27:27,040
year so it's getting thicker and fatter

629
00:27:31,470 --> 00:27:28,750
because water swells up a little bit

630
00:27:35,460 --> 00:27:31,480
because it gets warmer that's among the

631
00:27:37,350 --> 00:27:35,470
oceans and if you combine the ice that's

632
00:27:39,420 --> 00:27:37,360
falling in off the air Greenland

633
00:27:43,470 --> 00:27:39,430
Antarctica with a warming of the oceans

634
00:27:47,520 --> 00:27:43,480
the sea height goes up and here we see

635
00:27:51,540 --> 00:27:47,530
were measuring sea level from space

636
00:27:53,520 --> 00:27:51,550
using lasers from 93 to 2015 and that's

637
00:27:55,380 --> 00:27:53,530
about three inches just gone up about

638
00:27:57,690 --> 00:27:55,390

three inches over that time I've

639
00:28:02,850 --> 00:27:57,700
actually seen the sea level all around

640
00:28:08,669 --> 00:28:05,250
so what's going to happen well we think

641
00:28:10,649 --> 00:28:08,679
because the ice loss were the most

642
00:28:13,620 --> 00:28:10,659
likely between now and the end of this

643
00:28:17,370 --> 00:28:13,630
century 2100 sea level will rise

644
00:28:18,120 --> 00:28:17,380
probably one to three feet something

645
00:28:20,820 --> 00:28:18,130
like that

646
00:28:23,810 --> 00:28:20,830
about that much quite a lot which is not

647
00:28:26,899 --> 00:28:23,820
a problem in DC but in Florida and

648
00:28:32,149 --> 00:28:26,909
Bangladesh and a lot of coastal regions

649
00:28:36,149 --> 00:28:34,980
so all my friends who work on the ice

650
00:28:37,590 --> 00:28:36,159
they like to go out there and you see

651
00:28:40,110 --> 00:28:37,600
them working away on the ice if you look

652
00:28:41,340 --> 00:28:40,120
there's two interested spectators the

653
00:28:43,710 --> 00:28:41,350
Penguins always like to come and watch

654
00:28:45,389 --> 00:28:43,720
people working away you see us -

655
00:28:47,490 --> 00:28:45,399
penguins standing there at the edge on

656
00:28:50,509 --> 00:28:47,500
top there and they just sit there taking

657
00:28:54,810 --> 00:28:50,519
notes and see what they can find out

658
00:28:56,110 --> 00:28:54,820
they're curious creatures you saw

659
00:28:58,510 --> 00:28:56,120
penguin

660
00:29:02,260 --> 00:28:58,520
good for you

661
00:29:05,169 --> 00:29:02,270
so this is a computer model of Earth so

662
00:29:06,790 --> 00:29:05,179
all the satellite observations we get we

663
00:29:09,910 --> 00:29:06,800

put in a computer model to combine them

664
00:29:11,860 --> 00:29:09,920
and two gazillion calculations and can

665
00:29:14,020 --> 00:29:11,870
calculate the movement of air currents

666
00:29:16,180 --> 00:29:14,030
and clouds and you can see this looks

667
00:29:18,870 --> 00:29:16,190
like the real thing this is a computer

668
00:29:21,370 --> 00:29:18,880
simulation and we use it for prediction

669
00:29:23,710 --> 00:29:21,380
weather prediction and another version

670
00:29:25,030 --> 00:29:23,720
but climate prediction but look how

671
00:29:26,830 --> 00:29:25,040
realistic it is you can see all the

672
00:29:29,410 --> 00:29:26,840
little cumulus clouds a little puffy

673
00:29:31,780 --> 00:29:29,420
clouds you can see giant streams of air

674
00:29:33,940 --> 00:29:31,790
going across the oceans you can see ice

675
00:29:35,680 --> 00:29:33,950
coming and going and snow coming and

676
00:29:37,120 --> 00:29:35,690
going over the land and you can see the

677
00:29:40,299 --> 00:29:37,130
green is changing this is all a

678
00:29:42,730 --> 00:29:40,309
simulation but a realistic one it's a

679
00:29:45,450 --> 00:29:42,740
little toy world and that's what we use

680
00:29:47,590 --> 00:29:45,460
to try and understand the earth system

681
00:29:51,340 --> 00:29:47,600
that's how we try and make sense of it

682
00:29:54,250 --> 00:29:51,350
all so is this useful yeah you bet here

683
00:29:57,700 --> 00:29:54,260
comes sandy there comes sandy look at it

684
00:29:58,299 --> 00:29:57,710
well three days ahead before it turned

685
00:30:01,210 --> 00:29:58,309
left

686
00:30:03,370 --> 00:30:01,220
whacked into New York and New Jersey we

687
00:30:05,500 --> 00:30:03,380
knew it was going to do that with high

688
00:30:07,180 --> 00:30:05,510

confidence we knew that's going to head

689
00:30:10,000 --> 00:30:07,190
out in the Atlantic and then turn left

690
00:30:12,010 --> 00:30:10,010
and come back in why was that useful

691
00:30:13,690 --> 00:30:12,020
well everybody in New Jersey in New York

692
00:30:15,160 --> 00:30:13,700
was happy because they got to know three

693
00:30:17,500 --> 00:30:15,170
days ahead of time that he was going to

694
00:30:19,720 --> 00:30:17,510
hit them but think of all the people on

695
00:30:21,940 --> 00:30:19,730
the eastern seaboard who didn't live in

696
00:30:24,640 --> 00:30:21,950
New Jersey or New York who did not have

697
00:30:26,620 --> 00:30:24,650
to evacuate who didn't have to pick up

698
00:30:28,990 --> 00:30:26,630
everything and go so as a massive

699
00:30:31,390 --> 00:30:29,000
avoided cost from knowing what the

700
00:30:33,250 --> 00:30:31,400
weather's going to do to you this wasn't

701
00:30:36,250 --> 00:30:33,260
possible 20 years ago wasn't even

702
00:30:37,720 --> 00:30:36,260
possible ten years ago so what's one

703
00:30:42,040 --> 00:30:37,730
advantage of the whole satellite

704
00:30:43,120 --> 00:30:42,050
modeling system tells you a lot so this

705
00:30:45,370 --> 00:30:43,130
is what the world's going to look like

706
00:30:48,190 --> 00:30:45,380
in 20 years I'm just kidding it's the

707
00:30:49,840 --> 00:30:48,200
Sun that's all right there's a Sun all

708
00:30:51,700 --> 00:30:49,850
right this is a picture of some taken

709
00:30:53,500 --> 00:30:51,710
from another satellite and these things

710
00:30:55,570 --> 00:30:53,510
are called coronal mass ejections are

711
00:30:57,820 --> 00:30:55,580
really cool this is where the Sun throws

712
00:30:59,590 --> 00:30:57,830
out a whole lot of gas and stuff and it

713
00:31:00,200 --> 00:30:59,600

gets twisted around in magnetic fields

714
00:31:02,330 --> 00:31:00,210
and falls by

715
00:31:03,740 --> 00:31:02,340
down again very dramatic but you don't

716
00:31:06,740 --> 00:31:03,750
wanna get too close you'll lose your

717
00:31:09,530 --> 00:31:06,750
eyebrows some people thought for a while

718
00:31:12,110 --> 00:31:09,540
that changes in the solar output how

719
00:31:13,880 --> 00:31:12,120
productive how hot the Sun was made

720
00:31:16,100 --> 00:31:13,890
changes in weather well if that's true

721
00:31:18,110 --> 00:31:16,110
over the millions and millions of years

722
00:31:20,510 --> 00:31:18,120
time scale or the billions of year time

723
00:31:22,340 --> 00:31:20,520
scale but it's not the cause of the

724
00:31:24,590 --> 00:31:22,350
recent warming is the carbon dioxide

725
00:31:26,180 --> 00:31:24,600
that we're putting in the atmosphere but

726
00:31:31,460 --> 00:31:26,190
it's a cool picture don't this how to

727
00:31:34,220 --> 00:31:31,470
show it talk about that so all the

728
00:31:37,220 --> 00:31:34,230
wisdom all the models and things that we

729
00:31:39,320 --> 00:31:37,230
use one graph this is the sort of

730
00:31:42,350 --> 00:31:39,330
billion dollar graph if you like I

731
00:31:47,210 --> 00:31:42,360
wanted just the amount of warming that

732
00:31:50,120 --> 00:31:47,220
we can expect to get a country exact is

733
00:31:52,520 --> 00:31:50,130
completely how much oil and gas we burn

734
00:31:55,370 --> 00:31:52,530
so I want you to look at whether it says

735
00:31:57,230 --> 00:31:55,380
500 gigatons of carbon burn on the

736
00:31:59,000 --> 00:31:57,240
bottom that's where we are now we've

737
00:32:03,710 --> 00:31:59,010
increased to the earth by one degree

738
00:32:05,810 --> 00:32:03,720

grade that's one Fahrenheit from the

739
00:32:08,450 --> 00:32:05,820
beginning of the revolution I've got a

740
00:32:09,710 --> 00:32:08,460
bit of coal and decided to burn it not a

741
00:32:10,310 --> 00:32:09,720
bad thing that's why we all have these

742
00:32:14,120 --> 00:32:10,320
beautiful

743
00:32:15,770 --> 00:32:14,130
you know buildings good luck without

744
00:32:17,990 --> 00:32:15,780
your dust revolution I wouldn't be

745
00:32:20,630 --> 00:32:18,000
standing here with a clicker alright so

746
00:32:24,170 --> 00:32:20,640
here for that but you can see if we kept

747
00:32:25,970 --> 00:32:24,180
doing what we're doing is unlikely the

748
00:32:27,590 --> 00:32:25,980
coal there was we'd have a very hot

749
00:32:29,630 --> 00:32:27,600
planet four degrees warmer and that

750
00:32:33,170 --> 00:32:29,640
wouldn't be very healthy in a lot of

751
00:32:35,210 --> 00:32:33,180
places so somewhere between now and 2100

752
00:32:36,580 --> 00:32:35,220
we're probably going to change did we do

753
00:32:39,760 --> 00:32:36,590
things

754
00:32:41,140 --> 00:32:39,770
and by every indication to be able to

755
00:32:45,820 --> 00:32:41,150
level off somewhere between two and

756
00:32:48,550 --> 00:32:45,830
three degree walk quite likely why do i

757
00:32:51,550 --> 00:32:48,560
why my optimistic that people make the

758
00:32:55,600 --> 00:32:51,560
right choice because we have an example

759
00:32:56,980 --> 00:32:55,610
who here remembers the ozone hole there

760
00:32:58,630 --> 00:32:56,990
you go so there was a hole in the ozone

761
00:32:59,560 --> 00:32:58,640
over there's over Antarctica we could

762
00:33:03,310 --> 00:32:59,570
see it with a satellite

763
00:33:05,920 --> 00:33:03,320

oh no it's growing through the 80s and

764
00:33:09,610 --> 00:33:05,930
90s than the early 2000s so what

765
00:33:11,950 --> 00:33:09,620
happened well the scientist said it's

766
00:33:13,600 --> 00:33:11,960
happening they reported the satellite

767
00:33:15,610 --> 00:33:13,610
data they went down to Antarctica

768
00:33:18,060 --> 00:33:15,620
measured all the ozone they did all that

769
00:33:20,260 --> 00:33:18,070
stuff and then they came and told the UN

770
00:33:22,000 --> 00:33:20,270
and the UN got all the countries in the

771
00:33:26,110 --> 00:33:22,010
world and they signed all these treaties

772
00:33:27,370 --> 00:33:26,120
that reduced the amount of material that

773
00:33:28,990 --> 00:33:27,380
was going up there that was eating up

774
00:33:30,580 --> 00:33:29,000
the ozone hole took years I mean look

775
00:33:32,500 --> 00:33:30,590
all these treaties it took forever to do

776
00:33:34,240 --> 00:33:32,510
it you've probably heard the Montreal

777
00:33:35,770 --> 00:33:34,250
Protocol was the first one by the way

778
00:33:37,840 --> 00:33:35,780
there's one of our scientists sitting at

779
00:33:39,490 --> 00:33:37,850
the back eating some chips that's

780
00:33:41,440 --> 00:33:39,500
putting his name is Paul Newman he's not

781
00:33:42,820 --> 00:33:41,450
related to the other Paul Newman but he

782
00:33:45,270 --> 00:33:42,830
was one of the guys who found the ozone

783
00:33:47,440 --> 00:33:45,280
hole and did the work to persuade

784
00:33:52,600 --> 00:33:47,450
politicians that poor you ought to do

785
00:33:54,610 --> 00:33:52,610
something about it so as a result of you

786
00:33:56,260 --> 00:33:54,620
know policymakers working really hard to

787
00:33:58,750 --> 00:33:56,270
understand the problem and passing the

788
00:34:01,360 --> 00:33:58,760

right laws we have the world that's

789
00:34:03,520 --> 00:34:01,370
projected if we hadn't done anything and

790
00:34:04,780 --> 00:34:03,530
the world avoided sorry the world

791
00:34:06,190 --> 00:34:04,790
projected which is what we think it's

792
00:34:08,800 --> 00:34:06,200
going to happen now we've got these laws

793
00:34:10,180 --> 00:34:08,810
in place and the world avoided which

794
00:34:12,370 --> 00:34:10,190
what would have happened if we'd kept

795
00:34:15,100 --> 00:34:12,380
eating away at the ozone hole and right

796
00:34:16,930 --> 00:34:15,110
about 2040 you can see there's a zone is

797
00:34:19,150 --> 00:34:16,940
almost disappearing in the right hand

798
00:34:21,940 --> 00:34:19,160
screen which is what would have happened

799
00:34:24,010 --> 00:34:21,950
at this point you've got crop damage a

800
00:34:26,560 --> 00:34:24,020
lot of health there are a lot of health

801
00:34:28,470 --> 00:34:26,570
risks to people the plankton on the

802
00:34:32,290 --> 00:34:28,480
surface ocean is in pretty bad shape

803
00:34:33,970 --> 00:34:32,300
so we avoided that and woke up we did

804
00:34:36,790 --> 00:34:33,980
things we avoided that and we expect to

805
00:34:39,010 --> 00:34:36,800
have actually a world that's pre ozone

806
00:34:41,470 --> 00:34:39,020
hole by the 2060s will be back to where

807
00:34:44,490 --> 00:34:41,480
we should be so we will have fixed the

808
00:34:48,490 --> 00:34:44,500
problem not bad

809
00:34:52,720 --> 00:34:48,500
so reasons for optimism this is the

810
00:34:54,760 --> 00:34:52,730
world in Christmas 1968 and there's

811
00:34:57,730 --> 00:34:54,770
three billion people out there on that

812
00:34:59,290 --> 00:34:57,740
planet minus three because three of them

813
00:35:02,710 --> 00:34:59,300

had to be in a spacecraft taking this

814
00:35:08,980 --> 00:35:02,720
photo okay so three billion people in

815
00:35:12,670 --> 00:35:08,990
1968 and here is seven billion people

816
00:35:13,840 --> 00:35:12,680
now in all the cities of the world more

817
00:35:17,200 --> 00:35:13,850
than half them in the cities of the

818
00:35:19,570 --> 00:35:17,210
world now 7 billion people minus six who

819
00:35:23,170 --> 00:35:19,580
are on Space Station okay there you go

820
00:35:24,790 --> 00:35:23,180
so there's a lot of us there so you know

821
00:35:26,560 --> 00:35:24,800
so far we've managed to do a pretty good

822
00:35:28,570 --> 00:35:26,570
job of getting from 3 billion to 7

823
00:35:29,650 --> 00:35:28,580
billion without you know totally

824
00:35:32,100 --> 00:35:29,660
destroying the planet we're doing quite

825
00:35:35,490 --> 00:35:32,110
well so that's why I'm optimistic

826
00:35:38,200 --> 00:35:35,500
because I believe that everybody is born

827
00:35:40,720 --> 00:35:38,210
all you young people out there you're

828
00:35:42,550 --> 00:35:40,730
smart you're resourceful and you bring

829
00:35:44,950 --> 00:35:42,560
the solutions with you that will help

830
00:35:46,870 --> 00:35:44,960
get us where we should be going and fix

831
00:35:49,000 --> 00:35:46,880
the problems that confront us I have

832
00:35:51,460 --> 00:35:49,010
great faith in the resourcefulness of

833
00:35:57,930 --> 00:35:51,470
human beings so with that I'll stop

834
00:36:02,700 --> 00:35:59,490
come have a seat and we'll do some

835
00:36:07,319 --> 00:36:02,710
questions all right that was me by the

836
00:36:10,440 --> 00:36:07,329
way I wasn't the ID back good lucky well

837
00:36:11,970 --> 00:36:10,450
I wanted to ask a question first as an

838
00:36:13,710 --> 00:36:11,980

astronaut and someone who's traveled T

839
00:36:16,470 --> 00:36:13,720
International Space Station you're

840
00:36:18,480 --> 00:36:16,480
travelling about 220 miles above the

841
00:36:21,150 --> 00:36:18,490
earth how far up are the satellites that

842
00:36:22,710 --> 00:36:21,160
are making these observations very few

843
00:36:24,270 --> 00:36:22,720
of them are down there because there's

844
00:36:26,339 --> 00:36:24,280
quite a lot of drag from the atmosphere

845
00:36:29,579 --> 00:36:26,349
most of them the ones that was showing

846
00:36:32,640 --> 00:36:29,589
there up there at about 700 kilometers

847
00:36:34,620 --> 00:36:32,650
which is about 500 miles 500 miles up

848
00:36:37,589 --> 00:36:34,630
but they still go around the world about

849
00:36:39,480 --> 00:36:37,599
one hour every takes up an hour and 40

850
00:36:41,640 --> 00:36:39,490
minutes to get around and when you were

851
00:36:43,829 --> 00:36:41,650
up in space those different times did

852
00:36:45,660 --> 00:36:43,839
you make any observations of your own

853
00:36:47,550 --> 00:36:45,670
either with a photograph or just your

854
00:36:49,920 --> 00:36:47,560
eyes of changes that you were seeing

855
00:36:52,920 --> 00:36:49,930
over the course of those years one thing

856
00:36:54,510 --> 00:36:52,930
there was Pavan see changes over the

857
00:36:57,270 --> 00:36:54,520
between the missions that I could tell

858
00:37:02,609 --> 00:36:57,280
but you could see where people were you

859
00:37:05,210 --> 00:37:02,619
could see the cities in the West like

860
00:37:08,160 --> 00:37:05,220
Europe and North America are very clean

861
00:37:09,540 --> 00:37:08,170
so the last 20 years apparently that all

862
00:37:11,490 --> 00:37:09,550
the Clean Air Act's have cleaned up the

863
00:37:14,010 --> 00:37:11,500

air over the cities the air is good a

864
00:37:17,430 --> 00:37:14,020
lot of the industrial centers in India

865
00:37:18,420 --> 00:37:17,440
and China very thick smog you see

866
00:37:21,460 --> 00:37:18,430
they're still because they're still

867
00:37:26,980 --> 00:37:23,140
to do their industry let's go to a

868
00:37:29,349 --> 00:37:26,990
question from the audience when you um

869
00:37:31,599 --> 00:37:29,359
go into speech how do you when you're

870
00:37:35,230 --> 00:37:31,609
very close to the earth how do you not

871
00:37:37,300 --> 00:37:35,240
fall down how do you not fall down on

872
00:37:41,260 --> 00:37:37,310
there okay like when you're very close

873
00:37:44,080 --> 00:37:41,270
to it let me take that video it's one of

874
00:37:47,980 --> 00:37:44,090
these amazing things though what happens

875
00:37:50,440 --> 00:37:47,990
is if you go really really fast around

876
00:37:53,859 --> 00:37:50,450
the world if you go really fast

877
00:37:55,420 --> 00:37:53,869
you are falling but the world is curving

878
00:37:56,830 --> 00:37:55,430
away from you at the same rate that

879
00:37:58,210 --> 00:37:56,840
you're falling so you're always falling

880
00:38:00,730 --> 00:37:58,220
we just keep falling around the world

881
00:38:02,500 --> 00:38:00,740
you never actually hit it you have to be

882
00:38:06,150 --> 00:38:02,510
going very fast to do that you have to

883
00:38:09,270 --> 00:38:06,160
be going five miles per second alright

884
00:38:12,010 --> 00:38:09,280
that's fast good question

885
00:38:17,970 --> 00:38:12,020
next question for uh we have an online

886
00:38:22,900 --> 00:38:20,470
what technological advancements in your

887
00:38:27,460 --> 00:38:22,910
career has had the greatest impact on

888
00:38:30,370 --> 00:38:27,470

our ability to study the earth I would

889
00:38:31,930 --> 00:38:30,380
say it's a combination of things to my

890
00:38:33,820 --> 00:38:31,940
mind it's been a combination of

891
00:38:37,030 --> 00:38:33,830
satellite senses that we wouldn't even

892
00:38:39,310 --> 00:38:37,040
dreamed off you know 30 years ago 30

893
00:38:41,050 --> 00:38:39,320
years ago we're using stuffers not much

894
00:38:42,400 --> 00:38:41,060
better than the TV camera to look at the

895
00:38:44,859 --> 00:38:42,410
world now we're looking at it in all

896
00:38:47,230 --> 00:38:44,869
different ways we using radars and all

897
00:38:48,609 --> 00:38:47,240
kinds of instruments and that's good I

898
00:38:50,680 --> 00:38:48,619
mean we're seeing things you never seen

899
00:38:52,650 --> 00:38:50,690
before but to my mind the thing that's

900
00:38:55,359 --> 00:38:52,660
made the biggest difference really is

901
00:38:57,579 --> 00:38:55,369
computing power you know we've got

902
00:38:59,640 --> 00:38:57,589
computers now that can I mean my iPhone

903
00:39:01,320 --> 00:38:59,650
now could do more than

904
00:39:03,660 --> 00:39:01,330
sort of computers when I was a college

905
00:39:06,090 --> 00:39:03,670
student that would take up a room

906
00:39:09,180 --> 00:39:06,100
so computing powers are managed to

907
00:39:11,910 --> 00:39:09,190
allowed us to simulate the world at a

908
00:39:15,750 --> 00:39:11,920
very fine resolution very realistically

909
00:39:18,330 --> 00:39:15,760
not possible 20 years ago it's a huge

910
00:39:21,330 --> 00:39:18,340
help it's really tough to do it all by

911
00:39:25,470 --> 00:39:21,340
hand let me tell you we have another

912
00:39:28,170 --> 00:39:25,480
question from the audience how did you

913
00:39:35,730 --> 00:39:28,180

get the camera got your head

914
00:39:37,350 --> 00:39:35,740
that's right had to show us how did you

915
00:39:40,020 --> 00:39:37,360
get the camera from the moon

916
00:39:41,970 --> 00:39:40,030
Oh earlier we had an Apollo 11

917
00:39:43,470 --> 00:39:41,980
Hasselblad camera here in hey she wants

918
00:39:45,240 --> 00:39:43,480
to know how we got that from the moon

919
00:39:47,040 --> 00:39:45,250
the astronauts actually brought that

920
00:39:48,990 --> 00:39:47,050
back with them it was with them in the

921
00:39:50,460 --> 00:39:49,000
spacecraft when they came back and you

922
00:39:52,260 --> 00:39:50,470
can actually go just a few doors down

923
00:39:54,810 --> 00:39:52,270
here over in our milestones of flight

924
00:39:57,030 --> 00:39:54,820
gallery and see the spacecraft it came

925
00:39:58,280 --> 00:39:57,040
back in so it was protected as it came

926
00:40:00,930 --> 00:39:58,290
back through the atmosphere

927
00:40:10,920 --> 00:40:00,940
yeah and it's government property so

928
00:40:13,020 --> 00:40:10,930
those guys they have to how many days

929
00:40:15,750 --> 00:40:13,030
did it take you how to come back to

930
00:40:18,600 --> 00:40:15,760
earth how many days does it take to come

931
00:40:20,520 --> 00:40:18,610
back okay you know what this is amazing

932
00:40:21,960 --> 00:40:20,530
when you're going around the world on

933
00:40:24,840 --> 00:40:21,970
the space station or in Space Shuttle

934
00:40:28,590 --> 00:40:24,850
and the engines kick in to bring you

935
00:40:31,470 --> 00:40:28,600
back to earth I'm Space Shuttle about an

936
00:40:33,720 --> 00:40:31,480
hour later you're back on the ground

937
00:40:36,750 --> 00:40:33,730
takes an hour now if you like the moon

938
00:40:39,539 --> 00:40:36,760

and you decide to come back it takes

939
00:40:42,059 --> 00:40:39,549
about two and a half days two and a half

940
00:40:44,759 --> 00:40:42,069
days you're falling all the way home it

941
00:40:49,019 --> 00:40:44,769
takes about two and a half days another

942
00:40:51,569 --> 00:40:49,029
question from the audience if if this

943
00:40:52,859 --> 00:40:51,579
day time may be good to the moon will

944
00:40:55,470 --> 00:40:52,869
still be dark

945
00:41:00,750 --> 00:40:55,480
oh so if it's daytime here is gonna be

946
00:41:03,509 --> 00:41:00,760
dark on the moon no if you if you look

947
00:41:05,190 --> 00:41:03,519
up sometimes during the day you can see

948
00:41:08,250 --> 00:41:05,200
the moon on a very clear day have you

949
00:41:09,720 --> 00:41:08,260
ever seen that you ever seen that yeah

950
00:41:12,839 --> 00:41:09,730
the moon goes around the world very

951
00:41:14,700 --> 00:41:12,849
slowly so for like half the time it's

952
00:41:17,609 --> 00:41:14,710
bright and you can see it and the other

953
00:41:19,360 --> 00:41:17,619
half time it's it's darker you can see

954
00:41:22,960 --> 00:41:19,370
it during the day too

955
00:41:24,630 --> 00:41:22,970
an online question we do have an online

956
00:41:27,640 --> 00:41:24,640
question next

957
00:41:29,170 --> 00:41:27,650
how has atmospheric pollution changed

958
00:41:34,300 --> 00:41:29,180
over time is it something to be

959
00:41:36,360 --> 00:41:34,310
concerned about okay well there's that's

960
00:41:38,380 --> 00:41:36,370
a complicated question but first of all

961
00:41:40,030 --> 00:41:38,390
let's talk about the atmospheric

962
00:41:42,640 --> 00:41:40,040
pollution that surround the cities

963
00:41:45,130 --> 00:41:42,650

around industry that has got a lot

964
00:41:47,290 --> 00:41:45,140
better a lot better in the developed

965
00:41:49,210 --> 00:41:47,300
world over the last 20 years and we can

966
00:41:51,550 --> 00:41:49,220
see that from space we can see how all

967
00:41:55,240 --> 00:41:51,560
the cities in Europe and in North

968
00:41:57,100 --> 00:41:55,250
America have cleaned up enormous Lea so

969
00:41:59,710 --> 00:41:57,110
you can all be thankful for you know all

970
00:42:00,940 --> 00:41:59,720
the legislation that did that in other

971
00:42:02,920 --> 00:42:00,950
parts of the world I said earlier

972
00:42:04,900 --> 00:42:02,930
pollution around cities has actually got

973
00:42:07,600 --> 00:42:04,910
worse because people are developing very

974
00:42:09,880 --> 00:42:07,610
fast the thing that you know as most

975
00:42:12,310 --> 00:42:09,890
worry to earth scientists like me is the

976
00:42:15,130 --> 00:42:12,320
increase in carbon dioxide over time

977
00:42:17,230 --> 00:42:15,140
which gives you a climate change but

978
00:42:19,000 --> 00:42:17,240
that increase in carbon dioxide isn't

979
00:42:20,800 --> 00:42:19,010
dangerous to you and me health-wise you

980
00:42:23,410 --> 00:42:20,810
know I breathe in a little bit more

981
00:42:26,860 --> 00:42:23,420
carbon dioxide it doesn't hurt me it is

982
00:42:28,620 --> 00:42:26,870
what it does the climate system another

983
00:42:31,230 --> 00:42:28,630
question from the audience

984
00:42:33,210 --> 00:42:31,240
how heavy is the spacesuit even when

985
00:42:35,940 --> 00:42:33,220
your anyway there's no gravity on a moon

986
00:42:38,520 --> 00:42:35,950
one how heavy is the spacesuit when

987
00:42:42,300 --> 00:42:38,530
you're wearing a spacesuit it's heavy

988
00:42:44,760 --> 00:42:42,310

it's about three times as much well two

989
00:42:47,370 --> 00:42:44,770
times as much as I weigh just a

990
00:42:50,100 --> 00:42:47,380
spacesuit but when you're in space

991
00:42:54,060 --> 00:42:50,110
you're weightless so you don't even feel

992
00:42:57,540 --> 00:42:54,070
it you don't even feel it but if I wore

993
00:43:00,690 --> 00:42:57,550
it on the ground at fall over another

994
00:43:05,720 --> 00:43:00,700
audience question what will happen if we

995
00:43:11,010 --> 00:43:05,730
still smell a burn cold till the 20th

996
00:43:14,220 --> 00:43:11,020
21st century up to 2,000 to the next

997
00:43:15,840 --> 00:43:14,230
century if we saw keep burning coal if

998
00:43:17,880 --> 00:43:15,850
we still keep burning coal at the rate

999
00:43:19,440 --> 00:43:17,890
that we're doing now all the way up

1000
00:43:21,810 --> 00:43:19,450
through 2100 and I think this is

1001
00:43:24,180 --> 00:43:21,820
unlikely for the reasons I said but if

1002
00:43:26,070 --> 00:43:24,190
we did we'd have a very warm world and

1003
00:43:28,920 --> 00:43:26,080
the climate patterns will be very

1004
00:43:31,050 --> 00:43:28,930
different and in fact when you get that

1005
00:43:32,550 --> 00:43:31,060
warm it's not really clear what kind of

1006
00:43:33,990 --> 00:43:32,560
a wall we would have have I think

1007
00:43:35,330 --> 00:43:34,000
there'll be quite a lot of problems so

1008
00:43:39,570 --> 00:43:35,340
I'm pretty sure between now and then

1009
00:43:44,130 --> 00:43:39,580
people like you will help figure out a

1010
00:43:46,150 --> 00:43:44,140
way to do things better another audience

1011
00:43:48,160 --> 00:43:46,160
question

1012
00:43:50,710 --> 00:43:48,170
what do laugh in like me you in a

1013
00:43:52,450 --> 00:43:50,720

spacesuit what does it feel like when

1014
00:43:55,120 --> 00:43:52,460
you're in a spacesuit it feels very

1015
00:43:57,850 --> 00:43:55,130
comfortable because the Spade is

1016
00:43:59,620 --> 00:43:57,860
floating and you're floating inside the

1017
00:44:01,510 --> 00:43:59,630
spacesuit so it gets kind of bumping off

1018
00:44:04,360 --> 00:44:01,520
the inside it's very very comfortable

1019
00:44:07,270 --> 00:44:04,370
and the thing that's not so comfortable

1020
00:44:08,920 --> 00:44:07,280
is when you try and move your hands or

1021
00:44:18,520 --> 00:44:08,930
your arms because the spacesuit fights

1022
00:44:20,080 --> 00:44:18,530
back another online question what has

1023
00:44:21,430 --> 00:44:20,090
been the most surprising thing you have

1024
00:44:27,100 --> 00:44:21,440
learned about the earth and all your

1025
00:44:30,340 --> 00:44:27,110
research well let's think about that I

1026
00:44:32,470 --> 00:44:30,350
was really surprised how big an

1027
00:44:35,020 --> 00:44:32,480
influence all the living things on the

1028
00:44:37,720 --> 00:44:35,030
world have on the climate system that

1029
00:44:39,250 --> 00:44:37,730
that was that basically the biology of

1030
00:44:42,160 --> 00:44:39,260
the earth has a big impact on the

1031
00:44:45,070 --> 00:44:42,170
climate and the way things work and in

1032
00:44:48,130 --> 00:44:45,080
fact that the whole biosphere is

1033
00:44:50,440 --> 00:44:48,140
reacting to the increase the changes the

1034
00:44:51,940 --> 00:44:50,450
increase in co2 by sucking down more

1035
00:44:54,400 --> 00:44:51,950
carbon dioxide is actually helping us

1036
00:44:57,040 --> 00:44:54,410
out so you know you have to take pay

1037
00:44:59,590 --> 00:44:57,050
attention to global biology which is

1038
00:45:01,770 --> 00:44:59,600

something we don't even fought off 30

1039
00:45:05,140 --> 00:45:01,780
years ago it's a brand new science

1040
00:45:06,940 --> 00:45:05,150
actually I want to jump in there we hear

1041
00:45:08,470 --> 00:45:06,950
a lot about deforestation especially in

1042
00:45:09,700 --> 00:45:08,480
the Amazon are we noticing a lot of

1043
00:45:12,520 --> 00:45:09,710
changes in that particular region

1044
00:45:14,500 --> 00:45:12,530
because of the loss of those plants know

1045
00:45:18,190 --> 00:45:14,510
what's happening there was a massive

1046
00:45:20,950 --> 00:45:18,200
loss deforestation with development

1047
00:45:24,220 --> 00:45:20,960
fifteen 20 years ago we've changed some

1048
00:45:26,140 --> 00:45:24,230
policies that slowed quite a lot and the

1049
00:45:28,240 --> 00:45:26,150
other thing is we've seen actually in

1050
00:45:29,590 --> 00:45:28,250
North America a large regrowth of

1051
00:45:31,720 --> 00:45:29,600
forests particularly on the eastern

1052
00:45:33,760 --> 00:45:31,730
seaboard all the way up and down around

1053
00:45:37,530 --> 00:45:33,770
here forests have been wheat growing

1054
00:45:41,980 --> 00:45:37,540
that's great another audience question

1055
00:45:44,560 --> 00:45:41,990
what do it look like in space with the -

1056
00:45:48,640 --> 00:45:44,570
we'll think his space look like what do

1057
00:45:51,040 --> 00:45:48,650
we look like here let me tell you what

1058
00:45:53,560 --> 00:45:51,050
you can see from up there you can look

1059
00:45:55,690 --> 00:45:53,570
down and you can look down at the city

1060
00:45:58,150 --> 00:45:55,700
and you can recognize the outline of the

1061
00:46:02,200 --> 00:45:58,160
city from York you know geography you

1062
00:46:03,670 --> 00:46:02,210
can see rivers you can see ship wakes

1063
00:46:06,280 --> 00:46:03,680

you know ships going across the ocean

1064
00:46:08,350 --> 00:46:06,290
you can even see airliner contrails

1065
00:46:10,750 --> 00:46:08,360
going across the Atlantic you can see

1066
00:46:12,460 --> 00:46:10,760
planes very slowly below you while

1067
00:46:14,470 --> 00:46:12,470
you're spacewalking pushing their way

1068
00:46:16,600 --> 00:46:14,480
across the Atlantic you can't see the

1069
00:46:18,820 --> 00:46:16,610
plane that you see the little white tail

1070
00:46:20,950 --> 00:46:18,830
coming out from behind it so you can

1071
00:46:24,120 --> 00:46:20,960
almost you can see things that people

1072
00:46:26,650 --> 00:46:24,130
make cities planes ships almost and

1073
00:46:28,290 --> 00:46:26,660
still go around the world in an hour and

1074
00:46:31,600 --> 00:46:28,300
a half so the world is a small place

1075
00:46:36,040 --> 00:46:31,610
it's a very small place another audience

1076
00:46:38,830 --> 00:46:36,050
question like how do you get the day's s

1077
00:46:41,380 --> 00:46:38,840
around over the earth to take pictures

1078
00:46:43,240 --> 00:46:41,390
how do we get the things up into space

1079
00:46:45,700 --> 00:46:43,250
that look down to take the pictures

1080
00:46:51,070 --> 00:46:45,710
great question that's the difficult bit

1081
00:46:53,680 --> 00:46:51,080
we use one of those a rocket so we use a

1082
00:46:55,150 --> 00:46:53,690
big rocket and the bit that ends up in

1083
00:46:57,670 --> 00:46:55,160
space is only about the size of a

1084
00:47:00,040 --> 00:46:57,680
refrigerator so you have a huge straight

1085
00:47:01,990 --> 00:47:00,050
rocket and the thing up there on the top

1086
00:47:05,560 --> 00:47:02,000
the side refrigerator but here's the

1087
00:47:08,170 --> 00:47:05,570
typical bit that thing is so so delicate

1088
00:47:10,870 --> 00:47:08,180

so precious so expensive and hard to

1089
00:47:13,000 --> 00:47:10,880
make I'm amazed it survives the ride up

1090
00:47:14,920 --> 00:47:13,010
into space and then it gets hot and gets

1091
00:47:16,510 --> 00:47:14,930
cold it shake it to bits on the way up

1092
00:47:18,640 --> 00:47:16,520
and this still works

1093
00:47:21,100 --> 00:47:18,650
so people have got really good at making

1094
00:47:23,280 --> 00:47:21,110
this stuff

1095
00:47:25,170 --> 00:47:23,290
online question

1096
00:47:27,890 --> 00:47:25,180
did your work as a Shuttle astronaut

1097
00:47:32,910 --> 00:47:27,900
relate directly to your climate research

1098
00:47:34,920 --> 00:47:32,920
honest answer not really so I was a

1099
00:47:38,670 --> 00:47:34,930
climate scientist before I became a

1100
00:47:40,620 --> 00:47:38,680
national and you know I think it's

1101
00:47:42,420 --> 00:47:40,630
useful to have people who know all parts

1102
00:47:44,730 --> 00:47:42,430
of our science and the astronaut office

1103
00:47:46,110 --> 00:47:44,740
and that was me but most of the time I

1104
00:47:49,220 --> 00:47:46,120
was worrying about how to build space

1105
00:47:54,000 --> 00:47:49,230
station along with all my friends

1106
00:47:57,120 --> 00:47:54,010
another audience question how do you

1107
00:48:00,960 --> 00:47:57,130
sleep in space without like voting with

1108
00:48:01,560 --> 00:48:00,970
all that that is a great question let me

1109
00:48:05,580 --> 00:48:01,570
let me

1110
00:48:07,740 --> 00:48:05,590
show you what happens to my friends when

1111
00:48:09,150 --> 00:48:07,750
they tried to go to sleep in space you

1112
00:48:11,460 --> 00:48:09,160
know first day or so they look like this

1113
00:48:17,730 --> 00:48:11,470

they get this sleeping bag tied to the

1114
00:48:19,260 --> 00:48:17,740
wall and they go like this and that's

1115
00:48:21,390 --> 00:48:19,270
because when you close your eyes and

1116
00:48:23,280 --> 00:48:21,400
start to go to sleep you feel like

1117
00:48:24,900 --> 00:48:23,290
you're falling you feel like you just

1118
00:48:26,190 --> 00:48:24,910
fell off a 10-story building because

1119
00:48:28,140 --> 00:48:26,200
your eyes aren't telling you their rings

1120
00:48:32,520 --> 00:48:28,150
the same and so some part of your braces

1121
00:48:34,260 --> 00:48:32,530
wake up so just to kind of fool yourself

1122
00:48:37,350 --> 00:48:34,270
you tie yourself to the wall using

1123
00:48:39,240 --> 00:48:37,360
bungee straps like this pretend you're

1124
00:48:41,700 --> 00:48:39,250
at home in bed but I always found it

1125
00:48:43,710 --> 00:48:41,710
hard to sleep in space but let me tell

1126
00:48:45,990 --> 00:48:43,720
you a story people who grew up there for

1127
00:48:48,090 --> 00:48:46,000
a long time like 4 1 2 3 months they get

1128
00:48:50,910 --> 00:48:48,100
used to it and I have a Russian friend

1129
00:48:54,510 --> 00:48:50,920
and you just look at me and say oh peers

1130
00:48:55,710 --> 00:48:54,520
I want to sleep now I never go to sleep

1131
00:49:00,610 --> 00:48:55,720
in the middle of the room and he just

1132
00:49:03,440 --> 00:49:00,620
flowed around but he was used to it

1133
00:49:07,850 --> 00:49:03,450
good question it's hard to sleep in

1134
00:49:10,480 --> 00:49:07,860
space it's very hard question is how

1135
00:49:13,640 --> 00:49:10,490
many plan is there up this face

1136
00:49:18,370 --> 00:49:13,650
how many planets how many planets all

1137
00:49:23,390 --> 00:49:21,020
around this our Sun but one of them got

1138
00:49:25,250 --> 00:49:23,400

demoted and it's not really a planet

1139
00:49:27,080 --> 00:49:25,260
anymore get kicked out of the girl they

1140
00:49:27,500 --> 00:49:27,090
tell you but let me tell you something

1141
00:49:29,060 --> 00:49:27,510
else

1142
00:49:32,800 --> 00:49:29,070
we've been looking around other stars

1143
00:49:35,810 --> 00:49:32,810
out there and we think we have found

1144
00:49:38,150 --> 00:49:35,820
3000 other planets just around the stars

1145
00:49:41,570 --> 00:49:38,160
that are closest to us every solar

1146
00:49:43,730 --> 00:49:41,580
system we look at has planets so we

1147
00:49:45,980 --> 00:49:43,740
think the galaxy is lousy with planets

1148
00:49:49,130 --> 00:49:45,990
they're all over the place all different

1149
00:49:52,040 --> 00:49:49,140
kinds shapes sizes lots like Jupiter big

1150
00:49:54,140 --> 00:49:52,050
fat gassy ones quite a few rocky planets

1151
00:49:56,210 --> 00:49:54,150
they're all over the place we found

1152
00:49:58,280 --> 00:49:56,220
three thousand so far just in ten years

1153
00:49:59,960 --> 00:49:58,290
of looking so that's going to be the

1154
00:50:02,330 --> 00:49:59,970
exciting thing for the new kids back

1155
00:50:05,000 --> 00:50:02,340
there is looking further and further out

1156
00:50:13,620 --> 00:50:05,010
and looking at planets more and more

1157
00:50:18,150 --> 00:50:16,920
can we make another planet probably we

1158
00:50:18,750 --> 00:50:18,160
could make another plan I think it'd be

1159
00:50:24,560 --> 00:50:18,760
hard

1160
00:50:30,330 --> 00:50:28,710
we do have an online question what was

1161
00:50:32,550 --> 00:50:30,340
the biggest setback in your researcher

1162
00:50:36,510 --> 00:50:32,560
or your career how did you overcome it

1163
00:50:41,690 --> 00:50:36,520

oh well that's that's that's a good

1164
00:50:43,890 --> 00:50:41,700
question I think the biggest setback

1165
00:50:46,320 --> 00:50:43,900
collectively for all of us who are

1166
00:50:49,440 --> 00:50:46,330
working on trying to build space station

1167
00:50:51,480 --> 00:50:49,450
in the astronaut office was the loss of

1168
00:50:52,770 --> 00:50:51,490
the space shuttle Columbia there was a

1169
00:50:55,440 --> 00:50:52,780
terrible thing you know we lost some

1170
00:50:57,060 --> 00:50:55,450
friends and the program just came to a

1171
00:51:00,050 --> 00:50:57,070
grinding halt for like two and a half

1172
00:51:03,000 --> 00:51:00,060
years that was really tough on everybody

1173
00:51:04,800 --> 00:51:03,010
tough on NASA tough on United States and

1174
00:51:07,590 --> 00:51:04,810
tough on the people who we lost and

1175
00:51:11,330 --> 00:51:07,600
their families we just worked hard and

1176
00:51:14,060 --> 00:51:11,340
got over came back

1177
00:51:16,310 --> 00:51:14,070
another audience question what was your

1178
00:51:18,050 --> 00:51:16,320
favorite time to go to the space the

1179
00:51:20,260 --> 00:51:18,060
first time you went there or the second

1180
00:51:24,110 --> 00:51:20,270
time you went or the third time oh

1181
00:51:28,700 --> 00:51:24,120
that's a great question you know what my

1182
00:51:31,730 --> 00:51:28,710
second mission was my favorite we

1183
00:51:33,290 --> 00:51:31,740
launched on the 4th of July

1184
00:51:36,170 --> 00:51:33,300
the only shuttle mission ever to launch

1185
00:51:39,380 --> 00:51:36,180
on the 4th of July so we we had burgers

1186
00:51:40,430 --> 00:51:39,390
for breakfast get us in the mood and it

1187
00:51:42,140 --> 00:51:40,440
was just a great mission

1188
00:51:44,240 --> 00:51:42,150

lots of spacewalks a lot of exciting

1189
00:51:46,130 --> 00:51:44,250
things happening it was a lot of fun now

1190
00:51:49,610 --> 00:51:46,140
I mentioned earlier that you took a pee

1191
00:51:51,290 --> 00:51:49,620
you took a replica Nobel Prize on that

1192
00:51:53,510 --> 00:51:51,300
mission tell the audience what else you

1193
00:51:55,400 --> 00:51:53,520
took on that measure yes so I called the

1194
00:51:57,380 --> 00:51:55,410
Royal Society of London says there

1195
00:51:59,150 --> 00:51:57,390
anything you'd like me to take up in

1196
00:52:01,870 --> 00:51:59,160
space they said yeah how about a piece

1197
00:52:05,240 --> 00:52:01,880
of Isaac Newton's apple tree

1198
00:52:07,580 --> 00:52:05,250
so when Isaac Newton died they soared up

1199
00:52:10,730 --> 00:52:07,590
his apple tree and kept it in the museum

1200
00:52:13,400 --> 00:52:10,740
so I took a piece up with me and then I

1201
00:52:15,410 --> 00:52:13,410
held it up there in space and I took my

1202
00:52:18,620 --> 00:52:15,420
hand away to see if it would fall like

1203
00:52:20,450 --> 00:52:18,630
the Apple I know it didn't but I know

1204
00:52:22,940 --> 00:52:20,460
and I did this for a school's lecture

1205
00:52:25,790 --> 00:52:22,950
and I said kids do you think Sir Isaac

1206
00:52:29,030 --> 00:52:25,800
would have been fooled by this no Isaac

1207
00:52:31,220 --> 00:52:29,040
would have known that actually the bit

1208
00:52:33,110 --> 00:52:31,230
of apple tree is falling but so is the

1209
00:52:35,000 --> 00:52:33,120
whole space station around it falling at

1210
00:52:38,630 --> 00:52:35,010
the same rate so it doesn't appear to

1211
00:52:41,069 --> 00:52:38,640
move so Sir Isaac would have known

1212
00:52:45,029 --> 00:52:41,079
we have another online question I'll

1213
00:52:47,910 --> 00:52:45,039

have to give it back by the way do you

1214
00:52:51,150 --> 00:52:47,920
ever dream about weightlessness yes I do

1215
00:52:54,509 --> 00:52:51,160
I do I dream about waist lessness and I

1216
00:52:56,700 --> 00:52:54,519
dream about going in from blinding light

1217
00:52:58,620 --> 00:52:56,710
to dark because when you're whipping

1218
00:53:01,410 --> 00:52:58,630
around the world in space that's what

1219
00:53:04,859 --> 00:53:01,420
happens Bryant blinding this beautiful

1220
00:53:07,109 --> 00:53:04,869
sunlight you've ever seen all the colors

1221
00:53:10,200 --> 00:53:07,119
as bright as anything BAM a few seconds

1222
00:53:11,970 --> 00:53:10,210
later pitch black your night time on the

1223
00:53:13,650 --> 00:53:11,980
backside of the world and you're seeing

1224
00:53:15,630 --> 00:53:13,660
thunderstorm flashes below that's a

1225
00:53:17,130 --> 00:53:15,640
compensation and the cities you're

1226
00:53:20,190 --> 00:53:17,140
seeing other things at night going on

1227
00:53:21,599 --> 00:53:20,200
below you but white black white black

1228
00:53:24,299 --> 00:53:21,609
it's kind of that's the way it is when

1229
00:53:26,160 --> 00:53:24,309
you're working around the world well

1230
00:53:28,380 --> 00:53:26,170
thank you so much for joining us today

1231
00:53:30,630 --> 00:53:28,390
we want to thank Boeing our sponsors of

1232
00:53:32,220 --> 00:53:30,640
the wetsuit and aerospace series dr.

1233
00:53:34,349 --> 00:53:32,230
Sellars for joining us and giving us a

1234
00:53:37,789 --> 00:53:34,359
really interesting tour of Earth from

1235
00:53:40,140 --> 00:53:37,799
outer space and also to NASA for their