1
00:00:06,360 --> 00:00:14,980
[Music]

2
00:00:18,080 --> 00:00:19,720
Behold the Earth,

3
00:00:21,660 --> 00:00:22,940
teaming with life,

4
00:00:24,280 --> 00:00:27,940
ideally suited for the development of human
civilization.

5
00:00:29,720 --> 00:00:32,720
It's no wonder that previous generations

6
00:00:33,280 --> 00:00:34,820
held the fundamental belief

7
00:00:35,780 --> 00:00:39,300
that the resources of the world were unlimited,

8
00:00:40,000 --> 00:00:41,530
that our planet

9
00:00:41,780 --> 00:00:44,980
with this ideal environment for life

10
00:00:45,140 --> 00:00:47,600
was provided for our benefit

11
00:00:48,560 --> 00:00:51,500
and that we bear no responsibility

12
00:00:51,750 --> 00:00:54,790
for ensuring that the Earth remains

13

00:00:54,790 --> 00:00:57,869
fertile for the development of our civilization.

14
00:00:58,920 --> 00:01:01,980
But as our population has grown,

15
00:01:02,500 --> 00:01:05,900
our appetite for energy has increased

16
00:01:06,080 --> 00:01:10,100
and in some cases we have misused our land.

17
00:01:10,940 --> 00:01:13,040
We can no longer assume

18
00:01:13,040 --> 00:01:17,160
that the Earth will remain eternally ideal

19
00:01:17,780 --> 00:01:20,660
for the advancement of our civilization

20
00:01:20,860 --> 00:01:23,500
or the quality of our life.

21
00:01:25,020 --> 00:01:27,780
Rather we will forevermore

22
00:01:28,600 --> 00:01:33,000
be called upon to heed that biblical admonition,

23
00:01:33,760 --> 00:01:38,140
we need to be wise stewards of creation.

24
00:01:39,660 --> 00:01:42,000
But how do we know what to do?

25
00:01:42,780 --> 00:01:45,560
How does the Earth really work?

26
00:01:45,780 --> 00:01:50,860
How could humans influence our climate or
sea levels or any other aspect

27
00:01:51,160 --> 00:01:54,700
of the habitability of our planet?

28
00:01:55,940 --> 00:01:57,420
Fortunately,

29
00:01:57,600 --> 00:02:03,360
as our technological civilization has grown
to where humans can affect the Earth,

30
00:02:04,090 --> 00:02:08,550
we have also been provided with the tools
to study the Earth

31
00:02:08,860 --> 00:02:10,500
and understand it,

32
00:02:10,500 --> 00:02:11,921
predict its future

33
00:02:12,470 --> 00:02:14,510
and determine the actions

34
00:02:14,510 --> 00:02:16,910
that will be most effective

35
00:02:17,300 --> 00:02:22,060
to protect our future for generations to come.

36
00:02:23,920 --> 00:02:26,620
In the early 1980s,

37
00:02:28,320 --> 00:02:32,280

we've been studying the individual components
of the Earth;

38
00:02:33,100 --> 00:02:39,040
the atmosphere through meteorology and atmospheric
chemistry, the oceans through oceanography,

39
00:02:39,040 --> 00:02:41,159
the land and its biology

40
00:02:41,159 --> 00:02:42,700
through ecology,

41
00:02:43,780 --> 00:02:46,300
but the Earth is more complicated than that.

42
00:02:47,920 --> 00:02:53,160
The atmosphere, the oceans, the biosphere,
the cryosphere are all coupled

43
00:02:53,379 --> 00:02:56,529
with complicated feedback mechanisms,

44
00:02:56,529 --> 00:02:58,629
governing their interactions.

45
00:02:59,989 --> 00:03:03,949
The Earth is not simply individual components.

46
00:03:04,280 --> 00:03:06,720
It is an integrated system

47
00:03:06,980 --> 00:03:09,800
that we need to understand is a system,

48
00:03:10,120 --> 00:03:11,920
if we are to predict

49

00:03:11,930 --> 00:03:15,030
the future of the Earth.

50
00:03:16,500 --> 00:03:18,740
In the late 1980s,

51
00:03:20,040 --> 00:03:24,880
NASA embraced the concept of Earth system
science

52
00:03:24,889 --> 00:03:26,859
by bringing to bear

53
00:03:26,859 --> 00:03:31,499
the most important resource for studying the
earth as a system,

54
00:03:31,940 --> 00:03:38,200
the global perspective of Earth that is provided
by orbiting spacecraft

55
00:03:38,900 --> 00:03:43,840
NASA undertook one of its most important programs,

56
00:03:44,159 --> 00:03:48,029
the Mission to the Planet Earth and the Earth
observing system

57
00:03:48,029 --> 00:03:52,010
with the Terra and the Aqua and the Aura satellites

58
00:03:52,010 --> 00:03:57,230
as the principal observatories for studying
the Earth as a system.

59
00:03:57,920 --> 00:04:02,620
Many satellites have been added to this fleet
of satellites

60

00:04:02,620 --> 00:04:07,900
observing the Earth and these satellites are
and will continue

61
00:04:07,900 --> 00:04:10,659
to provide comprehensive observations

62
00:04:10,659 --> 00:04:15,029
from which we can understand the earth and
develop the models

63
00:04:15,029 --> 00:04:18,049
that allow us to predict our future.

64
00:04:18,600 --> 00:04:20,500
In tonight's program,

65
00:04:20,740 --> 00:04:23,840
we are going to celebrate what we have learned

66
00:04:23,850 --> 00:04:29,120
about the key components of the Earth systems
since we embarked upon Mission to Planet Earth

67
00:04:29,120 --> 00:04:31,680
some three decades ago.

68
00:04:32,420 --> 00:04:34,620
But as we celebrate,

69
00:04:35,120 --> 00:04:36,820
all that we have learned,

70
00:04:37,100 --> 00:04:42,460
we need to be aware that we are in a race
against time.

71
00:04:43,080 --> 00:04:45,000
The Earth is changing.

72
00:04:45,380 --> 00:04:48,520
Human civilization is influencing the Earth.

73
00:04:48,530 --> 00:04:50,810
We need the best possible

74
00:04:50,810 --> 00:04:56,310
scientific understanding of all the factors
that will influence the future of the planet

75
00:04:56,310 --> 00:04:59,699
so that we can make wise policy decisions

76
00:04:59,699 --> 00:05:01,060
to protect

77
00:05:01,060 --> 00:05:02,610
and to preserve

78
00:05:02,610 --> 00:05:03,870
this planet

79
00:05:03,870 --> 00:05:06,810
on which our civilization depends

80
00:05:06,810 --> 00:05:11,790
and if need be adapt to the changes that will
come.

81
00:05:12,770 --> 00:05:14,759
We need to become

82
00:05:14,759 --> 00:05:17,669
and forevermore remain

83
00:05:17,669 --> 00:05:20,969
wise stewards of creation.

84
00:05:21,940 --> 00:05:25,580
We begin this evening with Gail Jackson;

85
00:05:25,760 --> 00:05:27,480
who will discuss the water cycle

86
00:05:27,880 --> 00:05:30,039
that is essential for life.

87
00:05:30,640 --> 00:05:32,460
Then Lola Fatoyinbo

88
00:05:33,160 --> 00:05:35,840
will talk about the carbon cycle

89
00:05:35,840 --> 00:05:38,220
which is driven by many events

90
00:05:38,220 --> 00:05:41,340
including changing forest covers

91
00:05:41,560 --> 00:05:47,930
and Thorsten Markus will examine the key ice
sheets of the Antarctic and Arctic

92
00:05:47,930 --> 00:05:50,449
and their role in sea level rise

93
00:05:50,449 --> 00:05:57,440
and finally Piers Sellers will wrap up with
all the tasks that still lie before us.

94
00:05:58,100 --> 00:05:59,380
Gail?

95
00:06:00,300 --> 00:06:07,820
[Applause]

96
00:06:07,840 --> 00:06:09,300
Thank you!

97
00:06:09,560 --> 00:06:11,500
Our Earth is a water planet

98
00:06:11,979 --> 00:06:16,479
from the oceans, ice, rivers, lakes and aquifers

99
00:06:16,480 --> 00:06:19,360
to the water suspended in our atmosphere,

100
00:06:19,360 --> 00:06:21,759
our Earth is definitely a water planet.

101
00:06:22,540 --> 00:06:24,300
Take a look at our lovely Earth,

102
00:06:24,300 --> 00:06:29,720
Did you know that 99.5% of that water is stored
in our salty seas?

103
00:06:29,980 --> 00:06:33,740
or locked up in glaciers and other inaccessible
locations?

104
00:06:33,740 --> 00:06:39,340
leaving precious little fresh water available
to support our life on Earth?

105
00:06:39,660 --> 00:06:45,460
So one of the vital signs of our Earth is
the water cycle and understanding it and knowing it

106
00:06:45,460 --> 00:06:49,060
will help us to monitor our freshwater
resources

107
00:06:49,069 --> 00:06:51,719
and we can do this by measuring

108
00:06:51,719 --> 00:06:57,999
where, how the water moves within our planet
and I will talk about that today.

109
00:06:59,920 --> 00:07:02,620
This is a cartoon of our water cycle.

110
00:07:03,200 --> 00:07:06,719
It shows the linkages between the surface
water,

111
00:07:06,719 --> 00:07:10,020
condensation, precipitation, and evaporation.

112
00:07:10,920 --> 00:07:15,439
The water cycle is a complex system that drives
the movement of water

113
00:07:15,439 --> 00:07:18,719
and actually heat and energy around our planet;

114
00:07:19,940 --> 00:07:22,720
let's start by exploring the role

115
00:07:22,729 --> 00:07:26,049
of our deep and vast oceans in the water cycle.

116
00:07:26,820 --> 00:07:30,640
As you can see in this visualization of satellite
data,

117
00:07:31,940 --> 00:07:36,980
the ocean surface temperatures are not uniform
around the oceans.

118

00:07:37,600 --> 00:07:39,380
The warm water is in red

119
00:07:39,720 --> 00:07:41,920
and the cool water is in blue;

120
00:07:42,200 --> 00:07:46,040
drive the movement of water and heat throughout
the oceans

121
00:07:46,050 --> 00:07:49,849
which can in turn then influence our weather
patterns

122
00:07:49,849 --> 00:07:53,789
such as might be seen during El Niño and
La Niña Years.

123
00:07:54,979 --> 00:07:59,389
Also, driving the movement of water in our
oceans is salinity.

124
00:07:59,389 --> 00:08:04,369
As shown in this visualization of Aquarius
satellite data from NASA

125
00:08:05,040 --> 00:08:07,460
where evaporation occurs,

126
00:08:07,460 --> 00:08:08,999
our oceans get saltier,

127
00:08:08,999 --> 00:08:10,150
it's shown in red,

128
00:08:10,150 --> 00:08:12,439
where precipitation falls,

129
00:08:12,439 --> 00:08:14,580

ice melts or rivers discharge

130
00:08:14,580 --> 00:08:18,320
our oceans get fresher as shown in the blue.

131
00:08:18,560 --> 00:08:24,560
As your ocean water becomes saltier it becomes
more dense and settles down to the bottom of the ocean

132
00:08:24,819 --> 00:08:29,079
and vice versa for the less salty water which
rises to the top.

133
00:08:30,140 --> 00:08:31,640
Taken together,

134
00:08:32,200 --> 00:08:33,960
surface temperatures,

135
00:08:34,340 --> 00:08:38,740
salinity and also the ocean winds, the winds
above the ocean,

136
00:08:39,300 --> 00:08:41,560
combine in a complex dance

137
00:08:41,560 --> 00:08:44,190
that drives the ocean circulation patterns

138
00:08:44,190 --> 00:08:45,730
as shown here.

139
00:08:46,380 --> 00:08:49,940
The oceans also store massive amounts of heat

140
00:08:49,940 --> 00:08:52,520
and are very slow to release it

141

00:08:52,520 --> 00:08:57,540
which makes them a major driver in our Earth's climate system.

142
00:08:59,620 --> 00:09:03,040
The oceans and the atmosphere actually work together.

143
00:09:03,600 --> 00:09:05,120
Without the oceans,

144
00:09:05,120 --> 00:09:07,000
the water stays on surface

145
00:09:07,000 --> 00:09:09,500
and we need the atmosphere as well.

146
00:09:10,780 --> 00:09:14,660
For example, intense sunlight in the tropics

147
00:09:14,660 --> 00:09:17,880
causes evaporation from the salty oceans

148
00:09:17,880 --> 00:09:20,700
and that water forms in to massive clouds.

149
00:09:21,360 --> 00:09:25,280
Those massive clouds, that are moved by the atmospheric winds

150
00:09:25,280 --> 00:09:31,260
to the mid-latitudes where precipitation occurs either in the form of rain or snow.

151
00:09:31,980 --> 00:09:36,120
The only way to get a global perspective of precipitation patterns

152
00:09:36,120 --> 00:09:39,360

is to measure from spaceborne platforms.

153
00:09:39,360 --> 00:09:45,260
Six months ago NASA and the Japan Aerospace
Exploration Agency

154
00:09:45,400 --> 00:09:50,160
launched our joint Global Precipitation Measurement
Core Observatory Satellite

155
00:09:50,160 --> 00:09:52,240
or GPM for short.

156
00:09:54,060 --> 00:09:59,780
With two advanced instruments, the Core Observatory
for the first time is able to measure all

157
00:09:59,790 --> 00:10:01,570
phases of precipitation

158
00:10:01,570 --> 00:10:06,590
from very, very heavy rain to light rain to
falling snow.

159
00:10:07,420 --> 00:10:11,300
The GPM spacecraft serves as an anchor

160
00:10:11,310 --> 00:10:16,350
to a domestic and international constellation
of satellite partners,

161
00:10:16,350 --> 00:10:19,870
which collectively provide precipitation estimates

162
00:10:19,870 --> 00:10:23,090
everywhere in the world every three hours,

163
00:10:23,900 --> 00:10:28,640
in essence taking the pulse of the planet's

precipitation.

164
00:10:32,340 --> 00:10:39,540
This imagery shows one of the very first events
measured by the GPM spacecraft.

165
00:10:39,820 --> 00:10:45,680
It was one of the late-season falling snow
events here in East Coast on March 17.

166
00:10:46,570 --> 00:10:50,830
The resulting 7 inches of snow in the Washington
DC area

167
00:10:50,830 --> 00:10:54,470
may have affected your St. Patrick's Day plans
this year.

168
00:10:55,940 --> 00:10:57,800
Off the coast of the Carolinas,

169
00:10:57,810 --> 00:11:01,120
the high cloud tops are icy,

170
00:11:01,120 --> 00:11:05,000
down at the surface heavy rains shown in red
fell in the Atlantic Ocean.

171
00:11:05,200 --> 00:11:09,840
Farther North, over land, the storm has much
lower cloud tops

172
00:11:09,840 --> 00:11:13,980
and they are composed of snow shown in blue
which fell at the surface

173
00:11:13,980 --> 00:11:16,050
and we can see this information

174

00:11:16,050 --> 00:11:19,730
because the GPM spacecraft has two advanced instruments;

175
00:11:19,920 --> 00:11:20,940
one of them

176
00:11:20,940 --> 00:11:23,860
which I like to call the x-ray through the clouds

177
00:11:23,860 --> 00:11:26,930
measures the precipitation all way through the cloud

178
00:11:26,930 --> 00:11:29,830
and provides what I would call an x-ray at the surface.

179
00:11:29,830 --> 00:11:32,610
It's a two-dimensional view of the precipitation.

180
00:11:32,860 --> 00:11:36,200
The other instrument on board is what I like to call

181
00:11:36,200 --> 00:11:38,300
taking a CAT scan of the clouds

182
00:11:38,300 --> 00:11:41,430
and it takes layer by layer within the clouds

183
00:11:41,430 --> 00:11:43,220
information about the precipitation

184
00:11:43,220 --> 00:11:46,630
that's vital for helping us to understand precipitation

185

00:11:46,630 --> 00:11:50,230
and weather forecasting and climate models.

186
00:11:52,500 --> 00:11:55,120
So we're very excited about this data.

187
00:11:55,420 --> 00:11:59,400
Where else but NASA with our partners,

188
00:11:59,400 --> 00:12:03,520
are we able to achieve such success so early
in the mission?

189
00:12:03,880 --> 00:12:06,880
GPM also uses this data for applications

190
00:12:06,890 --> 00:12:09,330
to provide societal benefit.

191
00:12:09,330 --> 00:12:11,760
GPM observes hurricanes and blizzards

192
00:12:11,760 --> 00:12:14,540
but as shown in the top two panels here,

193
00:12:14,540 --> 00:12:20,020
we are also able to look at the conditions
that might lead to landslides and floods.

194
00:12:20,400 --> 00:12:26,600
On the other hand for trial and water availability
maps as shown in the bottom two images,

195
00:12:26,600 --> 00:12:29,670
we need to know how little it has precipitated
over time

196
00:12:29,670 --> 00:12:32,170
and GPM can tell us that too.

197
00:12:32,500 --> 00:12:35,600
Emergency management then can use this data

198
00:12:35,610 --> 00:12:39,290
in near real time to make evacuation plans.

199
00:12:42,140 --> 00:12:44,160
Precipitation in the water cycle

200
00:12:44,160 --> 00:12:48,660
influences every person, every day, everywhere,

201
00:12:49,320 --> 00:12:52,440
maybe one of the greatest impacts of NASA's
data

202
00:12:53,020 --> 00:12:58,620
is just used in improving weather forecasting
models and climate change models

203
00:12:58,630 --> 00:13:01,970
for our everyday lives and our long-term future.

204
00:13:02,900 --> 00:13:07,480
Now I would like introduce Lola who is going
to talk about the pulse of our planet's biosphere.

205
00:13:07,780 --> 00:13:15,460
[Applause]

206
00:13:15,640 --> 00:13:18,400
The most visual manifestation of life on earth

207
00:13:18,410 --> 00:13:21,590
happens every year when springtime comes

208
00:13:21,590 --> 00:13:25,690

and fresh green leaves and grasses appear
all around us.

209
00:13:25,690 --> 00:13:30,810
The biosphere, our living world is fueled
by the seasonal pulse of energy

210
00:13:30,810 --> 00:13:33,430
that the change in season brings.

211
00:13:33,660 --> 00:13:40,080
In this visualization, we can see the seasonal
changes to plants on land and in the oceans.

212
00:13:40,340 --> 00:13:44,920
Using data like these, we can estimate agricultural
yield worldwide,

213
00:13:45,200 --> 00:13:50,940
predict famines, fires and algae blooms or
help with land management.

214
00:13:51,140 --> 00:13:54,500
This global view of our biosphere is also
crucial

215
00:13:54,500 --> 00:13:57,370
for studying the flow of carbon to the Earth
system

216
00:13:57,370 --> 00:14:01,830
and predicting the rate and effect of climate
change on our home planet.

217
00:14:02,680 --> 00:14:06,100
In fact, the vegetation on land and in the
oceans

218
00:14:06,110 --> 00:14:09,130
are crucial component of the global carbon

cycle

219
00:14:09,130 --> 00:14:11,310
and climate change science.

220
00:14:11,600 --> 00:14:14,260
Plants are the real lungs of the Earth,

221
00:14:14,400 --> 00:14:17,080
absorbing the carbon dioxide from the atmosphere

222
00:14:17,080 --> 00:14:19,600
and producing the oxygen that we breathe.

223
00:14:19,640 --> 00:14:26,300
Here we see what's call net primary productivity;
maps of where and how much carbon is taken up

224
00:14:26,300 --> 00:14:29,560
or released by plants on a monthly basis.

225
00:14:29,700 --> 00:14:35,820
The colors are on these maps indicate how
fast carbon was taken in for every square meter of land

226
00:14:36,470 --> 00:14:40,050
and you could see how most of the change in
carbon uptake and emissions

227
00:14:40,050 --> 00:14:44,570
happens in the Northern Hemisphere where majority
of the land masses lie.

228
00:14:44,660 --> 00:14:50,640
Maps such as these, allow us scientists to
routinely monitor plant's role in the global carbon cycle

229
00:14:50,680 --> 00:14:55,560
and monitor how they're affecting and affected

by our changing climate.

230
00:14:57,500 --> 00:15:01,040
Carbon is emitted into the atmosphere from
natural sources

231
00:15:01,040 --> 00:15:06,420
such as forest clearing, decomposition, or
volcanic activity.

232
00:15:07,320 --> 00:15:11,920
90% of the non-natural emissions result from
power production,

233
00:15:11,930 --> 00:15:15,270
cement production and transportation.

234
00:15:16,580 --> 00:15:19,840
Over time 50% of that carbon that's emitted

235
00:15:19,850 --> 00:15:25,860
stays in the atmosphere while 25% gets taken
up by trees and plants

236
00:15:25,860 --> 00:15:29,900
and the remaining 25% is taken up by our oceans.

237
00:15:30,120 --> 00:15:35,260
And in fact, we can measure the contribution
in vegetation growth and human's emissions

238
00:15:35,260 --> 00:15:39,400
on the carbon that is stored in the atmosphere
using satellite data.

239
00:15:39,760 --> 00:15:45,540
So this visualization is a time series of
the global distribution and variation of carbon dioxide in the atmosphere

240

00:15:45,540 --> 00:15:49,130
as observed by NASA satellite since the year
2000.

241
00:15:49,130 --> 00:15:53,930
For comparison we've overlaid a graph of the
seasonal and inter-annual annual changed increase

242
00:15:53,930 --> 00:15:58,750
of carbon dioxide that was measured at the
Mauna Loa Observatory in Hawaii.

243
00:15:58,750 --> 00:16:00,680
So these data sets show us

244
00:16:00,680 --> 00:16:05,070
that the amount of carbon dioxide stored in
the atmosphere is steadily increasing

245
00:16:05,070 --> 00:16:08,370
as we continuously pump carbon into the atmosphere

246
00:16:08,370 --> 00:16:11,990
and decrease our forested and vegetated areas.

247
00:16:12,320 --> 00:16:17,600
And even though we still see that semi annual
dip in concentrations with the growth of

248
00:16:17,600 --> 00:16:19,670
vegetation in the springtime,

249
00:16:19,670 --> 00:16:25,850
the increasing trend of carbon dioxide concentrations
is leading to the warming and changing of our planet

250
00:16:30,440 --> 00:16:32,280
The seasonal pulse of vegetation growth

251

00:16:32,390 --> 00:16:35,630
is crucial for the well-being and balance
of life on Earth.

252
00:16:35,630 --> 00:16:39,320
This visualization of carbon dioxide concentrations
in the atmosphere

253
00:16:39,320 --> 00:16:44,570
shows how every springtime when forests, grasslands
and agricultural lands Green up

254
00:16:44,570 --> 00:16:48,290
they suck up the carbon dioxide contained
in the atmosphere

255
00:16:48,290 --> 00:16:49,550
through photosynthesis,

256
00:16:49,550 --> 00:16:53,550
but in the winter months that photosynthetic
uptake is not there and the large amounts

257
00:16:53,550 --> 00:16:56,560
of carbon dioxide stay in the atmosphere

258
00:16:56,560 --> 00:17:00,440
and in fact data from satellite sensors have
shown us

259
00:17:00,440 --> 00:17:03,320
that during the Northern Hemisphere's growing
season,

260
00:17:03,320 --> 00:17:05,620
the Midwest region of the United States

261
00:17:05,620 --> 00:17:07,760
boasts more photosynthetic activity

262
00:17:07,760 --> 00:17:10,180
than anywhere else on Earth.

263
00:17:11,040 --> 00:17:13,040
But with changes in the distribution

264
00:17:13,049 --> 00:17:15,100
and type of land cover on earth,

265
00:17:15,100 --> 00:17:18,870
the natural cycle of growth and carbon dioxide
uptake

266
00:17:18,870 --> 00:17:20,289
is being disturbed

267
00:17:20,289 --> 00:17:24,469
and more and more carbon dioxide is accumulating
in the atmosphere.

268
00:17:27,680 --> 00:17:34,360
Forest fires are one of the leading causes
of vegetation change and land use change emissions globally,

269
00:17:34,580 --> 00:17:38,700
but the cause of fires can be both natural
or human induced.

270
00:17:38,700 --> 00:17:43,370
In Africa forest fires are used to clear land
for agricultural activity

271
00:17:43,370 --> 00:17:48,240
and the amount and timing of fires is clearly
linked to the seasonal changes

272
00:17:48,240 --> 00:17:51,780
from healthy green vegetation to dry grasses

273
00:17:51,780 --> 00:17:57,960
leading to these sweeping waves of fire that
move from south to north and north to south each season

274
00:17:58,540 --> 00:18:01,980
As these areas are getting hotter and drier
with climate change,

275
00:18:01,990 --> 00:18:04,660
the intensity and amount of fire increases

276
00:18:04,660 --> 00:18:06,800
leading to even more clearing.

277
00:18:08,520 --> 00:18:13,740
But our satellite sensors don't just show
us the health and changes in vegetation on large scales.

278
00:18:14,080 --> 00:18:17,040
We can also monitor the human impact on our
planet

279
00:18:17,050 --> 00:18:19,770
on the scale of the city or our neighborhood.

280
00:18:19,880 --> 00:18:26,540
So this image series shows of the massive
growth spurt of Las Vegas since 1972.

281
00:18:26,660 --> 00:18:29,860
Those large red areas are actually green spaces

282
00:18:29,870 --> 00:18:34,040
such as city parks or golf courses

283
00:18:34,040 --> 00:18:36,130
but now take a look at Lake Mead

284

00:18:36,130 --> 00:18:39,900
we can see how with the influx of people into
the area,

285
00:18:39,900 --> 00:18:44,680
the water table is steadily decreasing.

286
00:18:46,800 --> 00:18:52,520
These images from Landsat really show us how
we humans have changed our planet.

287
00:18:52,530 --> 00:18:56,180
Here we see the impact of mountaintop removal
in West Virginia

288
00:18:56,180 --> 00:19:03,180
from 1984 to the present.

289
00:19:07,660 --> 00:19:11,520
In Saudi Arabia we're able to see how irrigation
technology

290
00:19:11,520 --> 00:19:14,080
has led to agriculture expansion in deserts

291
00:19:14,080 --> 00:19:20,100
but also to water table depletion in nearby
reservoirs.

292
00:19:20,100 --> 00:19:24,260
All of these examples

293
00:19:24,260 --> 00:19:27,470
are showing how we humans are changing the
look of the planet

294
00:19:27,470 --> 00:19:31,030
and consequently significantly affecting its
vital signs.

295
00:19:31,030 --> 00:19:36,070
Our last example shows a recent map of a forest
cover loss that is highlighted the extensive

296
00:19:36,070 --> 00:19:37,440
changes happening

297
00:19:37,440 --> 00:19:39,960
since just the year 2000.

298
00:19:39,960 --> 00:19:42,480
These images show forest clearing from wildfires

299
00:19:42,480 --> 00:19:46,320
in Colorado from 2000 to 2012

300
00:19:46,320 --> 00:19:49,560
fueled by record temperatures and dry conditions.

301
00:19:49,560 --> 00:19:53,130
In general, wildfires in the Western United
States

302
00:19:53,130 --> 00:19:55,860
are increasing in frequency and duration

303
00:19:55,860 --> 00:19:59,310
due to higher temperatures and longer growing
seasons

304
00:19:59,310 --> 00:20:03,070
and this has resulted in twice as many acres
burnt

305
00:20:03,070 --> 00:20:07,230
each year compared to just 40 years ago.

306
00:20:07,230 --> 00:20:10,550

These seasons are like the heartbeat of the planet,

307
00:20:10,550 --> 00:20:13,150
fueling the growth of vegetation worldwide

308
00:20:13,150 --> 00:20:17,090
and just as the seasons can affect the health of forested areas,

309
00:20:17,090 --> 00:20:21,180
they're also affecting the health of our ice caps and glaciers

310
00:20:21,180 --> 00:20:26,570
and on that note I would like to thank you for listening and introduce the next speaker,

311
00:20:26,570 --> 00:20:32,750
Dr. Thorsten Markus.

312
00:20:32,750 --> 00:20:34,809
[Applause]

313
00:20:34,809 --> 00:20:41,809
Good evening, thank you Lola and before I start I just wanted to say that Lola

314
00:20:42,890 --> 00:20:46,330
couple of years ago won the Presidential Early Career Award

315
00:20:46,330 --> 00:20:52,790
in Science and Engineering, super honor, congratulations.

316
00:20:52,790 --> 00:20:54,070
[Applause]

317
00:20:54,070 --> 00:20:57,050

So anyhow yeah we so anyhow we have good people
Goddard,

318
00:20:57,050 --> 00:20:59,250
incase you haven’t noticed.

319
00:20:59,250 --> 00:21:03,760
So now, let's get to the cool part of this
evening.

320
00:21:03,760 --> 00:21:09,680
The ice or we scientists call it lovingly
the cryosphere

321
00:21:09,680 --> 00:21:12,570
or we use fancy words to make it sound better.

322
00:21:12,570 --> 00:21:14,600
Now the bad news for the ice,

323
00:21:14,600 --> 00:21:16,250
the earth is getting warmer

324
00:21:16,250 --> 00:21:19,030
and that's just a fact and no matter what
you think about,

325
00:21:19,030 --> 00:21:22,120
global change, global warming et cetera,

326
00:21:22,120 --> 00:21:23,960
it is getting warmer

327
00:21:23,960 --> 00:21:27,520
and it's most pronounced at polar latitudes.

328
00:21:27,520 --> 00:21:30,170
It's especially true for the Arctic.

329
00:21:30,170 --> 00:21:33,120
We at Goddard, we have NASA I should say,

330
00:21:33,120 --> 00:21:37,570
we like to include JPL sometimes,

331
00:21:37,570 --> 00:21:41,800
we at Goddard and JPL a study of the Arctic
from the satellite.

332
00:21:41,800 --> 00:21:43,470
It's a very hostile environment;

333
00:21:43,470 --> 00:21:46,370
it's only with satellites that we have.

334
00:21:46,370 --> 00:21:50,690
Now a data record of what's going on in the
Arctic

335
00:21:50,690 --> 00:21:53,400
and the graph behind me,

336
00:21:53,400 --> 00:22:00,400
you see the temp of evolution of Arctic sea
ice during the summer.

337
00:22:00,660 --> 00:22:04,770
In the early years of microsatellite imagery

338
00:22:04,770 --> 00:22:11,070
it was relatively stable and scientist detected
a slight decrease and sea ice extent.

339
00:22:11,070 --> 00:22:14,200
But over the last year this trend has increased,

340
00:22:14,200 --> 00:22:16,610

the negative trend has increased tremendously

341
00:22:16,610 --> 00:22:20,059
and there is absolutely no doubt anymore from
many scientist

342
00:22:20,059 --> 00:22:25,300
that the Arctic sea ice is shrinking tremendously.

343
00:22:25,300 --> 00:22:29,059
These trends are statistically significant.

344
00:22:29,059 --> 00:22:30,500
To understand better what's going on

345
00:22:30,500 --> 00:22:33,830
we need to understand that the ice, the Arctic
sea ice,

346
00:22:33,830 --> 00:22:38,960
it's completely different from the frozen
lake in your neighborhood.

347
00:22:38,960 --> 00:22:42,059
It's a highly, very highly dynamic system.

348
00:22:42,059 --> 00:22:46,040
It moves around like a pulsating living being

349
00:22:46,040 --> 00:22:50,120
and you can see for example west of Greenland
and especially east of Greenland,

350
00:22:50,120 --> 00:22:53,080
these big streams, current of thick ice,

351
00:22:53,080 --> 00:22:55,650
it is leaving the Arctic system

352
00:22:55,650 --> 00:22:59,030
and it's way more than as I said a frozen
lake.

353
00:22:59,030 --> 00:23:01,680
There are constant openings and closing

354
00:23:01,680 --> 00:23:06,920
and these openings where the heat from the
ocean is getting into the atmosphere.

355
00:23:06,920 --> 00:23:08,710
It's a very complex system,

356
00:23:08,710 --> 00:23:10,760
it's very beautiful too I have to say

357
00:23:10,760 --> 00:23:14,650
and this is why it is so completed to predictions

358
00:23:14,650 --> 00:23:20,590
and if actually I could do prediction I would
become a stock broker.

359
00:23:20,590 --> 00:23:23,840
So if the ice is shrinking and thinning,

360
00:23:23,840 --> 00:23:30,840
it's more subjective to changes in the atmosphere
and oceanic conditions.

361
00:23:31,050 --> 00:23:37,330
The record minimum we observed in 2012 is
largely driven by the storm that developed

362
00:23:37,330 --> 00:23:38,290
over the arctic

363

00:23:38,290 --> 00:23:42,550
that moved a lot of ice out of the Arctic
ocean

364
00:23:42,550 --> 00:23:44,940
and so we are seeing these interactions

365
00:23:44,940 --> 00:23:48,230
between ocean atmosphere and ice

366
00:23:48,230 --> 00:23:52,170
more dramatically than we have seen in the
past when we had a more consolidated pack

367
00:23:52,170 --> 00:23:54,750
of ice pack.

368
00:23:54,750 --> 00:23:58,870
So we see these drastic changes in the Arctic,

369
00:23:58,870 --> 00:24:01,130
on the other side you see the Antarctic

370
00:24:01,130 --> 00:24:04,970
and people notice hey, what's going on, the
Arctic is changing,

371
00:24:04,970 --> 00:24:06,880
the Antarctic is not changing as much.

372
00:24:06,880 --> 00:24:10,650
As a matter of fact we see a slight increase
in the Antarctic.

373
00:24:10,650 --> 00:24:16,080
The reason is these are completely different...
completely different climate systems.

374
00:24:16,080 --> 00:24:18,160

For example, just to say one example,

375
00:24:18,160 --> 00:24:22,920
in the Arctic, at the North Pole we have ocean
which is surrounded by land.

376
00:24:22,920 --> 00:24:26,250
So the opposite is true,

377
00:24:26,250 --> 00:24:30,830
in the southern hemisphere we have land mass
which is surrounded by ocean

378
00:24:30,830 --> 00:24:33,770
and talking about land masses

379
00:24:33,770 --> 00:24:35,679
similar to the sea ice,

380
00:24:35,679 --> 00:24:38,059
the ice sheets are dynamic as well.

381
00:24:38,059 --> 00:24:40,809
Again it's not just a stable ice sheet.

382
00:24:40,809 --> 00:24:43,309
The way ice sheets work is it's snows,

383
00:24:43,309 --> 00:24:48,610
it's a center of the Arctic of the ice sheet
Antarctica or Greenland

384
00:24:48,610 --> 00:24:52,110
and this ice is slowly moving towards the
edges

385
00:24:52,110 --> 00:24:55,580
of the continent and breaks off as icebergs

386
00:24:55,580 --> 00:24:57,700
and if the system is imbalanced,

387
00:24:57,700 --> 00:25:04,570
the mass of snow equals the mass of the ice
bergs that are breaking off.

388
00:25:04,570 --> 00:25:08,760
In addition to this though, we have seen increased
melt,

389
00:25:08,760 --> 00:25:12,980
we had a record melt in Greenland a year or
two ago,

390
00:25:12,980 --> 00:25:15,000
and in addition to melt itself

391
00:25:15,000 --> 00:25:20,340
we know that some of the melt waters accumulate
as ponds on top of the ice,

392
00:25:20,340 --> 00:25:24,150
can drain to the bottom of the ocean... to
the bottom of the ice sheet

393
00:25:24,150 --> 00:25:28,640
and lubricate the interface between the ice
sheet and the bedrock,

394
00:25:28,640 --> 00:25:32,800
causing an extreme acceleration of glacier
flow.

395
00:25:32,800 --> 00:25:35,660
Some of the glaciers especially around Greenland

396
00:25:35,660 --> 00:25:38,590
accelerated for more than 100%.

397
00:25:38,590 --> 00:25:43,850
We have satellites that can actually directly
measure the mass of the ice sheets.

398
00:25:43,850 --> 00:25:48,950
One of the coolest concept, I mean as a physicist
I think it's a really cool concept, it's Grace,

399
00:25:48,950 --> 00:25:50,960
and Grace does not look upwards or downwards,

400
00:25:50,960 --> 00:25:54,910
it actually just measures the distance between
itself,

401
00:25:54,910 --> 00:26:01,690
between the two satellites and that with a
precision with less of the width of a hair.

402
00:26:01,690 --> 00:26:05,910
The first satellite goes over a field of high
gravity

403
00:26:05,910 --> 00:26:09,650
its accelerated ever so slightly and the distance
between the satellites increases

404
00:26:09,650 --> 00:26:16,110
until the second satellite is over the same
gravity hill

405
00:26:16,110 --> 00:26:18,460
and the distance becomes equal again.

406
00:26:18,460 --> 00:26:20,970
So using results from Grace,

407
00:26:20,970 --> 00:26:24,690

we can actually determine directly

408
00:26:24,690 --> 00:26:26,030
the mass of the ice sheets

409
00:26:26,030 --> 00:26:30,760
and if you look at the time series derived
from Grace over Greenland,

410
00:26:30,760 --> 00:26:34,559
we can see we have tremendous, tremendous
losses.

411
00:26:34,559 --> 00:26:41,559
We are losing right now about 200 gigatonnes
of ice every year, every year,

412
00:26:43,760 --> 00:26:46,660
so I can, to provide an analogy,

413
00:26:46,660 --> 00:26:52,500
it is a kilometer, by kilometer, by a kilometer
of ice is one gigatonne,

414
00:26:52,500 --> 00:26:55,679
or 200 gigatonnes, I did some math on my way
out here,

415
00:26:55,679 --> 00:27:00,710
200 gigatonnes of ice would cover the State
of California roughly, with half a meter.

416
00:27:00,710 --> 00:27:06,580
So, we can add, half a meter every year for
California.

417
00:27:06,580 --> 00:27:12,580
If Senator Nelson would still be here it is
almost equal to area in, I think its equal

418
00:27:12,580 --> 00:27:16,360
close to the area of Florida.

419
00:27:16,360 --> 00:27:21,020
So and then we launched ICESat-1 in 2003,

420
00:27:21,020 --> 00:27:23,690
this was a first laser alternator that surrounded
earth

421
00:27:23,690 --> 00:27:28,980
and we got a much better view in terms of
how is elevation changing around Greenland,

422
00:27:28,980 --> 00:27:29,730
around Antarctica

423
00:27:29,730 --> 00:27:35,850
and it provided the first measurement of Antarctica
as well as the Arctic sea ice.

424
00:27:35,850 --> 00:27:40,270
Before then, we were very pretty much blind
of the third dimension of the ice sheets and

425
00:27:40,270 --> 00:27:41,900
the sea ice.

426
00:27:41,900 --> 00:27:44,540
So it was a real cool mission and very NASA,
I think.

427
00:27:44,540 --> 00:27:51,540
ICESat-1 ended in 2009 and after that we started
a campaign

428
00:27:52,549 --> 00:27:55,929
called operation IceBridge.

429
00:27:55,929 --> 00:28:00,850
The scientist, and fortunately, headquarters
as well,

430
00:28:00,850 --> 00:28:06,830
realized we cannot afford to be completely
blind to the fast changing conditions in the

431
00:28:06,830 --> 00:28:08,240
climate regions.

432
00:28:08,240 --> 00:28:11,480
So we are flying twice a year,

433
00:28:11,480 --> 00:28:15,770
over the key regions in the Arctic as well
in the Antarctic,

434
00:28:15,770 --> 00:28:18,370
and instead of showing more data,

435
00:28:18,370 --> 00:28:23,380
I thought let's look just at some of the pictures
because I had the honor and the privilege

436
00:28:23,380 --> 00:28:25,080
of flying on some of these missions.

437
00:28:25,080 --> 00:28:26,929
It is just phenomenal flying over,

438
00:28:26,929 --> 00:28:33,230
it's 1500 feet, 500 meters, it is really close
flying over the ice sheets and sea ice.

439
00:28:33,230 --> 00:28:37,010
You fly over glacier and you have mountains
left and right.

440
00:28:37,010 --> 00:28:39,990
In addition to lasers, we have radars that
penetrate the ice,

441
00:28:39,990 --> 00:28:43,510
so we can actually measure the ice thickness
as well,

442
00:28:43,510 --> 00:28:50,510
and then of course, with all the objectivity
of a project scientist,

443
00:28:50,660 --> 00:28:54,020
in 2017, we launched ICESat-2,

444
00:28:54,020 --> 00:28:56,100
which is so cool and so phenomenal,

445
00:28:56,100 --> 00:29:00,540
and this is NASA at its best in my opinion,

446
00:29:00,540 --> 00:29:05,429
because it is ground breaking technology and
ground breaking science.

447
00:29:05,429 --> 00:29:10,110
With ICESat-1, we measured the earth every
150 meter,

448
00:29:10,110 --> 00:29:15,980
roughly, if you think about football, football
seasons are started, basically in the end

449
00:29:15,980 --> 00:29:16,570
zones.

450
00:29:16,570 --> 00:29:21,240
With ICESat-2, we measure with centimeter
precision,

451
00:29:21,240 --> 00:29:24,320
every yard line, which is really cool.

452
00:29:24,320 --> 00:29:27,920
And it will be a really discovery mission,

453
00:29:27,920 --> 00:29:30,340
and in addition to monitoring the ice sheets,

454
00:29:30,340 --> 00:29:32,670
we will monitor the height of trees,

455
00:29:32,670 --> 00:29:35,330
changes in the land, maybe tectonics,

456
00:29:35,330 --> 00:29:36,830
height of the oceans etcetera.

457
00:29:36,830 --> 00:29:39,260
It will be a real discovery mission,

458
00:29:39,260 --> 00:29:43,179
I am very, very excited about it, and worked very hard.

459
00:29:43,179 --> 00:29:46,059
When I was a young scientist, this is my last slide,

460
00:29:46,059 --> 00:29:50,600
just ten years ago, I went to Antarctica to measure sea ice thickness.

461
00:29:50,600 --> 00:29:52,830
This was then ten years ago,

462
00:29:52,830 --> 00:29:57,240

before ICESat-2 launched, the only way we could measure sea ice thickness,

463
00:29:57,240 --> 00:30:04,010
it was no other means. We went there and drilled lots and lots and lots of holes.

464
00:30:04,010 --> 00:30:04,910
It was great fun of course

465
00:30:04,910 --> 00:30:10,830
and we do had some visitors as well, as you could see at the top, what is it from your

466
00:30:10,830 --> 00:30:11,970
side, top left,

467
00:30:11,970 --> 00:30:18,230
isn't it amazing to just come out and look what we are doing?

468
00:30:18,230 --> 00:30:22,740
So, I think NASA does really cool stuff for cryosphere scientists

469
00:30:22,740 --> 00:30:25,929
and we have come a long way since ten years ago,

470
00:30:25,929 --> 00:30:30,160
when I went down there to take measurements of the ice

471
00:30:30,160 --> 00:30:37,160
and with this, I want to give the microphone to Piers Sellers former astronaut and my boss.

472
00:30:38,030 --> 00:30:41,850
[Applause]

473
00:30:41,850 --> 00:30:45,679
Thanks.

474
00:30:45,679 --> 00:30:48,160
So I have to treat Thorsten with a lot of
respect

475
00:30:48,160 --> 00:30:51,790
because he reminds me of Arnnie Schwarzenegger
with a PhD,

476
00:30:51,790 --> 00:30:55,840
I don't want to get on wrong side of him.

477
00:30:55,840 --> 00:31:00,860
So, okay, the view from orbit really does
put things in perspective

478
00:31:00,860 --> 00:31:03,750
and as Senator Nelson has seen this with his
own eyes,

479
00:31:03,750 --> 00:31:06,030
so he knows what I am talking about,

480
00:31:06,030 --> 00:31:10,299
I have enjoyed seeing the earth too with my
own eyes through a spacesuit visor,

481
00:31:10,299 --> 00:31:15,040
and I am absolutely fascinated by what a satellite
instruments can tell us.

482
00:31:15,040 --> 00:31:17,580
We, that's NASA and all our friends at NASA,

483
00:31:17,580 --> 00:31:21,650
are quite literally conducting a health check
of the planet.

484
00:31:21,650 --> 00:31:25,950
Okay, so these hands on working scientists
have dazzled with facts and data.

485
00:31:25,950 --> 00:31:29,190
It's my job, as a grizzled bureaucrat

486
00:31:29,190 --> 00:31:32,580
to drag this event over the finish line and
let you find your cars.

487
00:31:32,580 --> 00:31:34,360
So I will try and be quick.

488
00:31:34,360 --> 00:31:37,400
So here are a few closing thoughts.

489
00:31:37,400 --> 00:31:43,720
What all of this means for science, for policy
makers and for the crew spaceship Earth, that's

490
00:31:43,720 --> 00:31:46,070
all of us.

491
00:31:46,070 --> 00:31:49,429
Okay, this movie shows you what happens

492
00:31:49,429 --> 00:31:52,160
when we combine the satellite data with computer
models

493
00:31:52,160 --> 00:31:56,600
and use a lot of physics to fill in the gaps
between observations.

494
00:31:56,600 --> 00:31:58,990
Here we are on the space, this is not a snow
storm,

495
00:31:58,990 --> 00:32:02,950
these are solar particles blasting by the
earth but we are protected by magnetic field.

496
00:32:02,950 --> 00:32:05,320
So the particles are diverted.

497
00:32:05,320 --> 00:32:06,929
As we come down deeper,

498
00:32:06,929 --> 00:32:12,700
and by the way this is a model based on physics
and observations so there is fact and mathematics,

499
00:32:12,700 --> 00:32:14,090
Isaac Newton is hard at work here,

500
00:32:14,090 --> 00:32:18,950
here is the atmospheric flows, again produced
by a model,

501
00:32:18,950 --> 00:32:22,290
circulation timescales here are on hours to
days,

502
00:32:22,290 --> 00:32:26,100
so we come a little bit deeper in to the world,

503
00:32:26,100 --> 00:32:31,220
We see the surface winds. Now we are looking
at the surface, ocean circulation.

504
00:32:31,220 --> 00:32:34,720
Ms. Gail said that's forced by heat, wind
and salinity,

505
00:32:34,720 --> 00:32:36,960
timescales of days and months and years.

506
00:32:36,960 --> 00:32:41,700
Deep yet, and now I will talk with the French
accent like Jacques Cousteau,

507
00:32:41,700 --> 00:32:46,200
the sub surface flows down to the deep ocean
circulation,

508
00:32:46,200 --> 00:32:49,750
timescales of a thousand years or more.

509
00:32:49,750 --> 00:32:50,679
It's beautiful

510
00:32:50,679 --> 00:32:56,179
and we get all of this for combining the satellite
data with what we understand about nature

511
00:32:56,179 --> 00:32:58,549
and putting it in to a computer.

512
00:32:58,549 --> 00:33:01,309
This stuff is based on actual reality.

513
00:33:01,309 --> 00:33:02,350
Not the Kardashian kind,

514
00:33:02,350 --> 00:33:06,120
but let's get back to think about climate.

515
00:33:06,120 --> 00:33:09,440
So here is a computer model simulation of
the earth's climate system,

516
00:33:09,440 --> 00:33:12,340
this is not a picture, this is a simulation.

517

00:33:12,340 --> 00:33:14,980
It's a toy world based on physics

518
00:33:14,980 --> 00:33:16,530
and propelled by satellite data.

519
00:33:16,530 --> 00:33:19,190
I guess when you look at the detail here,

520
00:33:19,190 --> 00:33:25,210
the popcorn clouds, the winds, or the planetary
scale waves in the atmosphere.

521
00:33:25,210 --> 00:33:30,679
The snow, the ice, the biosphere, it's all
right there.

522
00:33:30,679 --> 00:33:34,160
It's all being calculated and it's all being
faithfully reproduced.

523
00:33:34,160 --> 00:33:36,830
Now what is this all good for?

524
00:33:36,830 --> 00:33:43,049
Well, models have got to the point of providing
weather prediction up to 72 hours reliably.

525
00:33:43,049 --> 00:33:47,510
You can quite literally bank on it, most days.

526
00:33:47,510 --> 00:33:51,530
This is going to be Hurricane Sandy, this
is actually a model prediction of Sandy

527
00:33:51,530 --> 00:33:55,500
and as you could see the Hurricane wandered
around the Atlantic before turning sharply

528

00:33:55,500 --> 00:33:59,330
left and whacking New Jersey and New York.

529
00:33:59,330 --> 00:34:03,230
But accurate warnings were given out 72 hours
ahead of time

530
00:34:03,230 --> 00:34:07,900
and many lives and a lot of money was saved
as a result of these warnings.

531
00:34:07,900 --> 00:34:10,099
By the way, speaking for us,

532
00:34:10,099 --> 00:34:14,409
that's not counting all the people up and
down the East Coast who did not have to evacuate,

533
00:34:14,409 --> 00:34:16,720
because they knew the Hurricane was going
to miss them all together,

534
00:34:16,720 --> 00:34:19,510
and that counts for something.

535
00:34:19,510 --> 00:34:20,990
Now the exact same physics

536
00:34:20,990 --> 00:34:23,849
and many of the same observations that we
use for weather

537
00:34:23,849 --> 00:34:26,779
are helping us to understand climate better.

538
00:34:26,779 --> 00:34:29,149
And these climate models allow us to peer
in to the future

539

00:34:29,149 --> 00:34:34,169
and will help us make decisions about energy,
water and food resources.

540
00:34:34,169 --> 00:34:40,979
Okay, this is a simulation of what we think
the earth will look like in 20 to 30 years.

541
00:34:40,979 --> 00:34:42,299
Actually it's not.

542
00:34:42,299 --> 00:34:44,239
It's the picture of the sun,

543
00:34:44,239 --> 00:34:48,309
it's being taken by our heliophysical friends
using their satellites.

544
00:34:48,309 --> 00:34:50,479
Besides being a really cool image,

545
00:34:50,479 --> 00:34:53,200
it shows that we are keeping a close eye on
the sun,

546
00:34:53,200 --> 00:34:55,079
again using satellites and guess what,

547
00:34:55,079 --> 00:35:00,680
we have found the sun to be not guilty for
the recent warming trend.

548
00:35:00,680 --> 00:35:03,609
Now as I said we use the same exact physics
and many of the same satellite data to be

549
00:35:03,609 --> 00:35:04,920
used in weather models

550

00:35:04,920 --> 00:35:07,549
to build and test our climate models.

551
00:35:07,549 --> 00:35:11,049
Now what these models do tell us

552
00:35:11,049 --> 00:35:16,190
is the rate of warming depends very largely
on how much fossil fuel we use and how much

553
00:35:16,190 --> 00:35:19,970
carbon dioxide we put in the atmosphere.

554
00:35:19,970 --> 00:35:21,479
I am now going to show you a graph

555
00:35:21,479 --> 00:35:25,160
and it is very bad form for even like this

556
00:35:25,160 --> 00:35:29,900
but in compensation it may be the most expensive
graph ever made

557
00:35:29,900 --> 00:35:32,170
and thats not because of the colors.

558
00:35:32,170 --> 00:35:34,079
This cost several years of effort

559
00:35:34,079 --> 00:35:37,339
by thousands of scientists worldwide to put
it together

560
00:35:37,339 --> 00:35:40,859
and it tell us something, we didn't know until
only recently.

561
00:35:40,859 --> 00:35:45,390
It's something new and something very, very

simple.

562
00:35:45,390 --> 00:35:50,039
What it says is that the expected rise in
temperature is directly,

563
00:35:50,039 --> 00:35:54,200
linearly related to the amount of fossil fuel
we burn.

564
00:35:54,200 --> 00:35:57,729
The X axis of the bottom shows how much fossil
fuel we burn

565
00:35:57,729 --> 00:35:59,509
which makes the carbon dioxide

566
00:35:59,509 --> 00:36:06,509
and the y-axis shows the temperature increase
that results from this extra Co2.

567
00:36:06,630 --> 00:36:09,839
The zero point is roughly or a bit left to
the zero point

568
00:36:09,839 --> 00:36:12,970
is roughly when fellow in England in 1700

569
00:36:12,970 --> 00:36:15,660
decided it was time to start an industrial
revolution

570
00:36:15,660 --> 00:36:17,869
and dug up the first pit of coal.

571
00:36:17,869 --> 00:36:21,390
Now, if you look at the black line that ends
at 2010,

572

00:36:21,390 --> 00:36:25,690
you'll see that we burned about 500 gigatonnes
of carbon since then

573
00:36:25,690 --> 00:36:28,309
and a gigatonne of carbon is a brick of coal

574
00:36:28,309 --> 00:36:31,470
about a kilometer on the side so it is a big
piece of coal

575
00:36:31,470 --> 00:36:36,089
and that's give us about 1° C rise in global
temperature

576
00:36:36,089 --> 00:36:37,609
which is what we have seen

577
00:36:37,609 --> 00:36:40,099
and that's led to some changes in the world

578
00:36:40,099 --> 00:36:43,519
that my good friend I've just shown you.

579
00:36:43,519 --> 00:36:46,529
Now we'll likely to burn 1000 gigatonnes,

580
00:36:46,529 --> 00:36:48,130
that's halfway up the graph,

581
00:36:48,130 --> 00:36:53,150
that will give us two degree centigrade to
two and half centigrade increase in global

582
00:36:53,150 --> 00:36:54,999
temperature.

583
00:36:54,999 --> 00:36:59,039
We definitely don't want to be up in the top

right-hand corner,

584
00:36:59,039 --> 00:37:00,329
four degree centigrade.

585
00:37:00,329 --> 00:37:04,140
This look like a very different planet than
the current Earth that we inhabit

586
00:37:04,140 --> 00:37:06,950
and we don't really know what that planet
would look like,

587
00:37:06,950 --> 00:37:09,609
how it would work,

588
00:37:09,609 --> 00:37:10,910
so this is sobering, right?

589
00:37:10,910 --> 00:37:15,599
but is it necessary going to be grim and nasty
to the maximum?

590
00:37:15,599 --> 00:37:21,799
Is this evening going to be a total downer
for you all if we don't count the refreshments?

591
00:37:21,799 --> 00:37:25,430
I think not and there is some basis for my
optimism.

592
00:37:25,430 --> 00:37:29,329
Here is a picture of the ozone hole that was
discovered in 1979.

593
00:37:29,329 --> 00:37:35,039
The blue color shows that ozone is being eaten
up by manmade chemicals, many refrigerants.

594

00:37:35,039 --> 00:37:40,380
We saw the hole growing rapidly in the 80s
and 90s

595
00:37:40,380 --> 00:37:41,579
and this was bad news

596
00:37:41,579 --> 00:37:43,630
because ozone protects most of life on Earth

597
00:37:43,630 --> 00:37:48,019
from strong ultraviolet radiation from the
sun and that's bad for you.

598
00:37:48,019 --> 00:37:54,829
But here is the good part of the story. Governments
all around the world took information seriously.

599
00:37:54,829 --> 00:37:59,309
Here is a UN meeting where they are discussing
the problem on what to do about it.

600
00:37:59,309 --> 00:38:01,599
It modeled on Goddard seminar.

601
00:38:01,599 --> 00:38:05,599
Here are all the agreements that they cranked
out

602
00:38:05,599 --> 00:38:09,660
to reduce the chemicals that cause the problem

603
00:38:09,660 --> 00:38:12,999
and here is two of Goddard's finest scientists
in the back row

604
00:38:12,999 --> 00:38:19,999
providing solid science advice and eating
chips, there they are.

605
00:38:20,079 --> 00:38:23,390
Alright, and what happened?

606
00:38:23,390 --> 00:38:27,119
Here is a picture of two worlds;

607
00:38:27,119 --> 00:38:29,960
on the left is world that we are likely to
see

608
00:38:29,960 --> 00:38:34,529
with the ozone depletion leveling off and
then slowly reversing

609
00:38:34,529 --> 00:38:36,039
and on the right is what would have happened

610
00:38:36,039 --> 00:38:38,539
if we didn't have all those controls and agreements

611
00:38:38,539 --> 00:38:42,999
and blue here means no ozone which is bad
news.

612
00:38:42,999 --> 00:38:44,849
On right-hand side is the world we avoided.

613
00:38:44,849 --> 00:38:47,039
That's the world with thinning ozone,

614
00:38:47,039 --> 00:38:50,769
a world with damage to all living things exposed
to sunlight

615
00:38:50,769 --> 00:38:53,950
and that includes the crops that provide our
food,

616

00:38:53,950 --> 00:38:56,210
the ocean plankton that makes our oxygen

617
00:38:56,210 --> 00:38:59,229
and damage to us, people.

618
00:38:59,229 --> 00:39:01,670
And now a news flash

619
00:39:01,670 --> 00:39:03,970
today at four o'clock

620
00:39:03,970 --> 00:39:06,349
United Nations released a statement.

621
00:39:06,349 --> 00:39:12,519
It reads, the Earth's protective ozone layer
is well on track to recovery in the next few

622
00:39:12,519 --> 00:39:13,729
decades

623
00:39:13,729 --> 00:39:18,220
thanks concerted international action against
ozone depleting substances

624
00:39:18,220 --> 00:39:22,239
according to a new assessment by 300 scientists.

625
00:39:22,239 --> 00:39:26,039
So it can be done,

626
00:39:26,039 --> 00:39:27,720
this is proof that people

627
00:39:27,720 --> 00:39:30,470
and that's all of us and our political representatives

628

00:39:30,470 --> 00:39:34,390
can use solid information, facts, models,

629
00:39:34,390 --> 00:39:36,900
like every thing we have seen tonight

630
00:39:36,900 --> 00:39:39,210
to make the right decisions.

631
00:39:39,210 --> 00:39:40,849
Now sometimes it happens a bit later,

632
00:39:40,849 --> 00:39:44,210
and it takes bit longer than we would like

633
00:39:44,210 --> 00:39:47,130
but generally the right decisions get made.

634
00:39:47,130 --> 00:39:54,130
Now there’s are a lot of people on this
planet.

635
00:39:54,470 --> 00:39:56,910
This is Christmas 1968

636
00:39:56,910 --> 00:40:02,190
3 billion people on Earth and there they all
are,

637
00:40:02,190 --> 00:40:09,190
actually we or some of us are, minus three
because somebody has to take the photo.

638
00:40:10,329 --> 00:40:16,059
Now here is a picture 2013 put together from
satellite data.

639
00:40:16,059 --> 00:40:20,190
Now there are 7 billion of us plus six on

space station

640
00:40:20,190 --> 00:40:25,239
and we will top out at about 9 billion this
century.

641
00:40:25,239 --> 00:40:27,400
But again I think there is reason for optimism
here

642
00:40:27,400 --> 00:40:32,319
because people are actually part of the solution.

643
00:40:32,319 --> 00:40:36,499
Every new human born is not just an extra
stress on the world

644
00:40:36,499 --> 00:40:41,999
but brings with himself or herself resources
and answers.

645
00:40:41,999 --> 00:40:46,539
This is an early picture of Len Fisk.

646
00:40:46,539 --> 00:40:50,460
So I think, I hope that with the ingenuity,

647
00:40:50,460 --> 00:40:54,410
the resourcefulness, the grit that has got
the human race so far

648
00:40:54,410 --> 00:40:58,339
we can use these vital signs about the health
of our planet

649
00:40:58,339 --> 00:41:03,109
to figure out how to live long and prosper
on this Earth.

650

00:41:03,109 --> 00:41:06,650
Now before I close up I'd like to recognize
the great work done by the visualization team,

651
00:41:06,650 --> 00:41:09,640
Ali Ogden, Wade Sisler, Rani Gran, Horace
Mitchell and friends

652
00:41:09,640 --> 00:41:11,880
who put all these beautiful pictures together

653
00:41:11,880 --> 00:41:15,680
and of course a huge thank you for all speakers
and sponsors so put your hand together please.