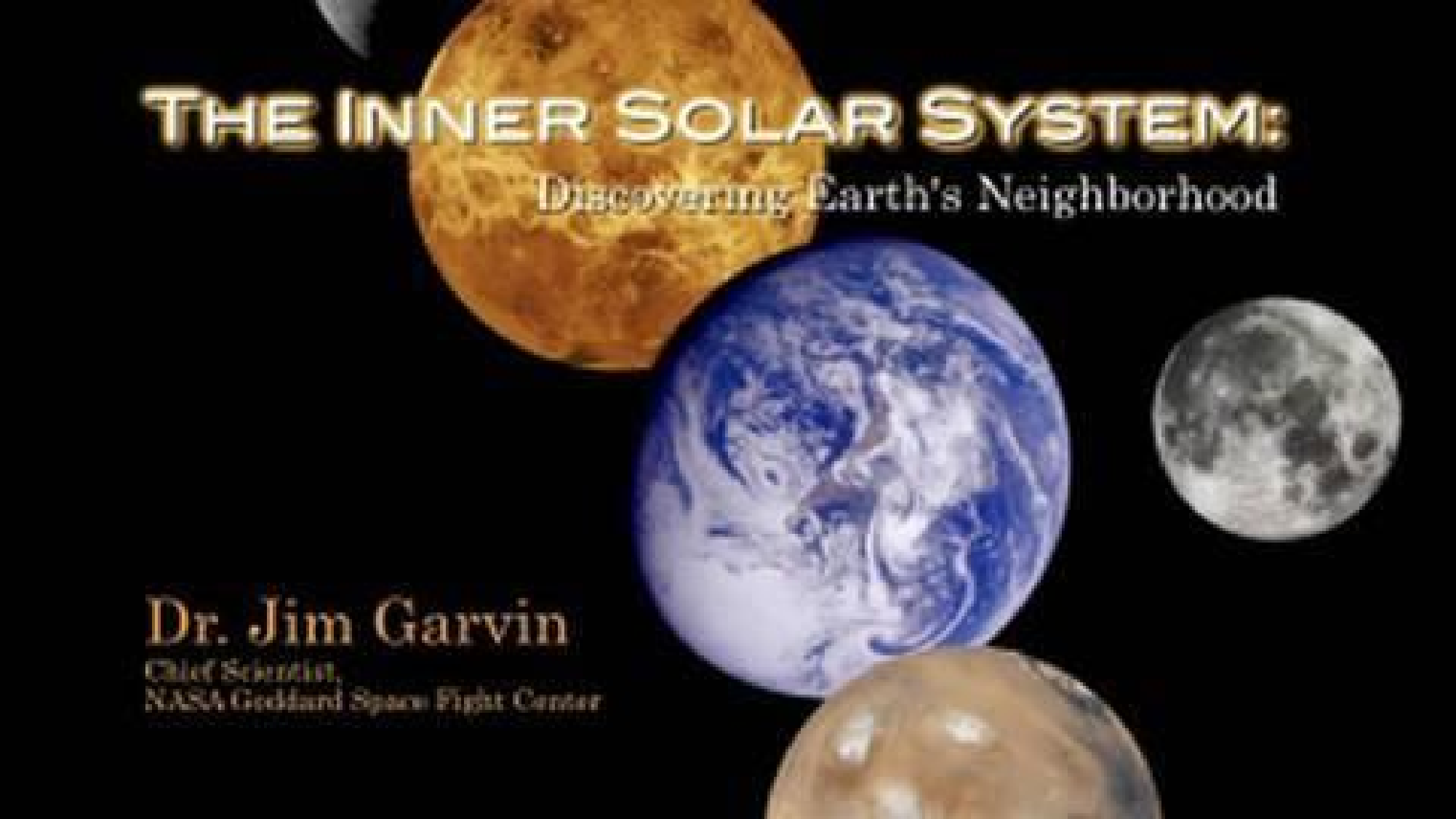
THE INNER SOLAR SYSTEM:
Discovering Earth's Neighborhood
Dr. Jim Garvin
Chief Scientist,
NASA Goddard Space Flight Center

1
00:00:18,470 --> 00:00:17,029
welcome everyone um today to a tour of

2
00:00:20,550 --> 00:00:18,480
our neighborhood the neighborhood in

3
00:00:22,550 --> 00:00:20,560
space and before i begin i'd like to

4
00:00:24,870 --> 00:00:22,560
remind everyone that it's important to

5
00:00:27,830 --> 00:00:24,880
recognize why space matters and why

6
00:00:29,990 --> 00:00:27,840
exploring near us on planet earth is

7
00:00:32,549 --> 00:00:30,000
really significant this is where we will

8
00:00:33,750 --> 00:00:32,559
go as people and since we live in space

9
00:00:36,310 --> 00:00:33,760
what's happened to our neighboring

10
00:00:38,709 --> 00:00:36,320
planets is actually extremely germane to

11
00:00:40,229 --> 00:00:38,719
how we understand ourselves in fact one

12
00:00:42,229 --> 00:00:40,239
of the themes i will have

13
00:00:44,229 --> 00:00:42,239

today is things we've learned about

14
00:00:46,950 --> 00:00:44,239
earth by looking at our nearest

15
00:00:49,190 --> 00:00:46,960
neighboring planets that starts with

16
00:00:50,630 --> 00:00:49,200
mercury and venus continues through our

17
00:00:52,310 --> 00:00:50,640
own moon and goes on to mars so i'm

18
00:00:54,549 --> 00:00:52,320
going to be talking about that part of

19
00:00:56,470 --> 00:00:54,559
the solar system and again right now is

20
00:00:58,229 --> 00:00:56,480
a really pivotal time for understanding

21
00:01:00,310 --> 00:00:58,239
this this region of the solar system

22
00:01:01,510 --> 00:01:00,320
because this is where some of you may

23
00:01:02,869 --> 00:01:01,520
get to go

24
00:01:05,030 --> 00:01:02,879
so it would be really pretty cool it's

25
00:01:07,030 --> 00:01:05,040
been a generation since any human being

26
00:01:08,550 --> 00:01:07,040
has gone back to deep space so we're

27
00:01:10,390 --> 00:01:08,560
going to talk about

28
00:01:11,429 --> 00:01:10,400
mercury the moon

29
00:01:14,230 --> 00:01:11,439
venus

30
00:01:15,749 --> 00:01:14,240
the earth and mars these are the worlds

31
00:01:17,510 --> 00:01:15,759
that formed in the same neck of the

32
00:01:20,149 --> 00:01:17,520
woods as our planet now a lot of people

33
00:01:23,270 --> 00:01:20,159
forget that the planets were all born in

34
00:01:25,270 --> 00:01:23,280
a rather tumultuous event about 4.7

35
00:01:27,350 --> 00:01:25,280
billion years ago a lot of energy

36
00:01:28,550 --> 00:01:27,360
condensing matter probably a lot of dark

37
00:01:30,870 --> 00:01:28,560
energy and dark matter that we don't

38
00:01:32,149 --> 00:01:30,880

understand yet and it led to these

39
00:01:34,069 --> 00:01:32,159
planets and one of the important things

40
00:01:35,510 --> 00:01:34,079
to remember is while we look for other

41
00:01:37,270 --> 00:01:35,520
earths

42
00:01:38,710 --> 00:01:37,280
and here's our earth we have to remember

43
00:01:39,590 --> 00:01:38,720
that our earth may not always look this

44
00:01:41,830 --> 00:01:39,600
way

45
00:01:43,590 --> 00:01:41,840
so the hallmarks of our planet the water

46
00:01:46,149 --> 00:01:43,600
planet the life planet why is it named

47
00:01:48,149 --> 00:01:46,159
earth people always ask in fact water is

48
00:01:49,590 --> 00:01:48,159
inextricably linked to everything we do

49
00:01:51,830 --> 00:01:49,600
but if you stripped off the water of our

50
00:01:53,910 --> 00:01:51,840
planet our planet would look remarkably

51
00:01:55,590 --> 00:01:53,920
in some ways like the planet of venus

52
00:01:57,670 --> 00:01:55,600
and so one of the things we do as we

53
00:01:59,830 --> 00:01:57,680
study the inner solar system is we do

54
00:02:01,990 --> 00:01:59,840
comparative planetology so here's the

55
00:02:04,310 --> 00:02:02,000
earth i've unloaded the oceans you can

56
00:02:06,469 --> 00:02:04,320
still see the islands in australia

57
00:02:08,790 --> 00:02:06,479
the 90 each ridge and many other

58
00:02:09,749 --> 00:02:08,800
features and realized that our solar

59
00:02:11,750 --> 00:02:09,759
system

60
00:02:13,190 --> 00:02:11,760
is really a very interesting place

61
00:02:14,790 --> 00:02:13,200
because of how the planets have

62
00:02:17,350 --> 00:02:14,800
developed our planet developed into the

63
00:02:19,350 --> 00:02:17,360

water planet now this little slide shows

64
00:02:21,589 --> 00:02:19,360
something rather embarrassing about how

65
00:02:24,309 --> 00:02:21,599
we see ourselves here's the earth and we

66
00:02:26,150 --> 00:02:24,319
have a time series for the planet earth

67
00:02:27,910 --> 00:02:26,160
based on the history of life

68
00:02:30,229 --> 00:02:27,920
we're a living planet so we have

69
00:02:32,470 --> 00:02:30,239
eocambrian or

70
00:02:34,630 --> 00:02:32,480
uh pre-phanerozoic and all these eras

71
00:02:36,470 --> 00:02:34,640
defined by fossils and things like that

72
00:02:38,710 --> 00:02:36,480
very important we've developed similar

73
00:02:40,309 --> 00:02:38,720
things based on other indicators for the

74
00:02:42,070 --> 00:02:40,319
moon and now mars and mercury and we

75
00:02:45,190 --> 00:02:42,080
have none for venus

76
00:02:46,949 --> 00:02:45,200
so our neighboring world venus 90 of the

77
00:02:48,470 --> 00:02:46,959
size of our own planet we haven't

78
00:02:50,070 --> 00:02:48,480
developed that kind of paradigm this is

79
00:02:51,830 --> 00:02:50,080
a real kind of embarrassing thing it'd

80
00:02:53,509 --> 00:02:51,840
be like having a sister and not knowing

81
00:02:55,110 --> 00:02:53,519
what she really looks like

82
00:02:57,270 --> 00:02:55,120
um i don't know whether that matters to

83
00:02:58,790 --> 00:02:57,280
you but to me as a planetary scientist i

84
00:03:00,070 --> 00:02:58,800
worry about not understanding this

85
00:03:01,910 --> 00:03:00,080
planet so we're going to come back to

86
00:03:03,910 --> 00:03:01,920
venus but we're going to start with the

87
00:03:05,030 --> 00:03:03,920
innermost solar system briefly because

88
00:03:08,309 --> 00:03:05,040

we're learning about it very

89
00:03:10,390 --> 00:03:08,319
dramatically move to venus the moon back

90
00:03:11,430 --> 00:03:10,400
to earth and on to mars and i hope

91
00:03:13,190 --> 00:03:11,440
you'll

92
00:03:14,470 --> 00:03:13,200
at least be inspired by what we've

93
00:03:16,630 --> 00:03:14,480
learned in the last couple decades

94
00:03:18,630 --> 00:03:16,640
because that's the lifespan of which a

95
00:03:21,910 --> 00:03:18,640
lot of the new data has has really borne

96
00:03:23,990 --> 00:03:21,920
fruit so right now as we speak a mission

97
00:03:26,309 --> 00:03:24,000
known as the messenger mission is

98
00:03:27,430 --> 00:03:26,319
inbound to the planet mercury

99
00:03:29,350 --> 00:03:27,440
and this mission is one of the most

100
00:03:31,030 --> 00:03:29,360
challenging in the history of women and

101
00:03:33,750 --> 00:03:31,040
men because it's trying to get to

102
00:03:35,589 --> 00:03:33,760
mercury the cheapest safest way and

103
00:03:37,750 --> 00:03:35,599
actually orbit a planet where the

104
00:03:39,350 --> 00:03:37,760
temperature cycles are the most extreme

105
00:03:41,430 --> 00:03:39,360
we can ever imagine on a spacecraft in

106
00:03:43,509 --> 00:03:41,440
fact much of the spacecraft is a giant

107
00:03:45,750 --> 00:03:43,519
sun shield to keep the temperatures of

108
00:03:47,750 --> 00:03:45,760
the electronics so it can do its work no

109
00:03:49,509 --> 00:03:47,760
spacecraft built by women or men has

110
00:03:51,110 --> 00:03:49,519
ever orbited mercury

111
00:03:53,110 --> 00:03:51,120
we've done two flyby missions back in

112
00:03:54,630 --> 00:03:53,120
the 70s and now this mission has flown

113
00:03:56,070 --> 00:03:54,640

by mercury twice

114
00:03:57,990 --> 00:03:56,080
changing our view of this world that

115
00:03:59,670 --> 00:03:58,000
looks remarkably like the moon the

116
00:04:00,470 --> 00:03:59,680
problem is that's not the way mercury

117
00:04:02,789 --> 00:04:00,480
works

118
00:04:05,990 --> 00:04:02,799
but this mission won't arrive to mercury

119
00:04:08,630 --> 00:04:06,000
to do its mapping until march 2011. so

120
00:04:11,429 --> 00:04:08,640
we're getting ready to unfold the real

121
00:04:13,589 --> 00:04:11,439
mysteries of a planet it's about a third

122
00:04:15,750 --> 00:04:13,599
the size of the earth's where we really

123
00:04:17,270 --> 00:04:15,760
don't know why its surface

124
00:04:19,349 --> 00:04:17,280
looks so much like the moon there are

125
00:04:21,189 --> 00:04:19,359
theories why it has a magnetic field the

126
00:04:23,350 --> 00:04:21,199
way it does whether at the poles of

127
00:04:24,790 --> 00:04:23,360
mercury there are actually ice sheets

128
00:04:27,110 --> 00:04:24,800
preserved inside craters so the

129
00:04:30,230 --> 00:04:27,120
messenger mission built by the applied

130
00:04:31,749 --> 00:04:30,240
physics lab competed by nasa is our new

131
00:04:34,469 --> 00:04:31,759
mission to that planet and starting in

132
00:04:36,390 --> 00:04:34,479
march 2011 we will be peeling back the

133
00:04:38,310 --> 00:04:36,400
veil of how the innermost planet and our

134
00:04:41,110 --> 00:04:38,320
solar system work this is the densest

135
00:04:44,150 --> 00:04:41,120
planet in the solar system okay it's a

136
00:04:45,749 --> 00:04:44,160
factor of 40 denser than the earth now

137
00:04:47,749 --> 00:04:45,759
to get to mercury

138
00:04:49,670 --> 00:04:47,759

the messenger spacecraft had to fly by

139
00:04:51,590 --> 00:04:49,680
and achieve a little nudge from the

140
00:04:53,590 --> 00:04:51,600
planet of venus and that's what we do we

141
00:04:55,030 --> 00:04:53,600
use the energy of the planets in the

142
00:04:57,270 --> 00:04:55,040
solar system to allow us to do what we

143
00:04:59,510 --> 00:04:57,280
do this is one glimmer of the new data

144
00:05:00,629 --> 00:04:59,520
the messenger is producing this is a

145
00:05:02,790 --> 00:05:00,639
color

146
00:05:04,870 --> 00:05:02,800
visible infrared map of the cratered

147
00:05:06,390 --> 00:05:04,880
region of mercury the colors represent

148
00:05:08,870 --> 00:05:06,400
different chemistries we see areas that

149
00:05:11,749 --> 00:05:08,880
are blue coated with a different type of

150
00:05:13,510 --> 00:05:11,759
soil or regolith we see these large

151
00:05:15,350 --> 00:05:13,520
compressive features we think mercury

152
00:05:16,950 --> 00:05:15,360
puckered because of the incredible

153
00:05:18,710 --> 00:05:16,960
incredible thermal load from being so

154
00:05:21,110 --> 00:05:18,720
close to the sun we see fresh craters

155
00:05:22,469 --> 00:05:21,120
where you see color patterns of the

156
00:05:24,950 --> 00:05:22,479
things that were ejected from them so

157
00:05:26,550 --> 00:05:24,960
there's mercury i wish i could tell you

158
00:05:29,270 --> 00:05:26,560
how this planet put itself together

159
00:05:30,150 --> 00:05:29,280
because we don't know however we have a

160
00:05:31,909 --> 00:05:30,160
mission

161
00:05:33,430 --> 00:05:31,919
to go it's not a place we would likely

162
00:05:35,590 --> 00:05:33,440
send any of you

163
00:05:37,990 --> 00:05:35,600

temperature extremes would not be

164
00:05:40,070 --> 00:05:38,000
prudent as a former president once said

165
00:05:42,150 --> 00:05:40,080
so missions of exploration to the

166
00:05:44,310 --> 00:05:42,160
planets in this follow in this coming

167
00:05:46,710 --> 00:05:44,320
decade will revolutionize how we see our

168
00:05:48,629 --> 00:05:46,720
innermost planet mercury and move on to

169
00:05:50,950 --> 00:05:48,639
other worlds so this is just one little

170
00:05:53,189 --> 00:05:50,960
piece of the data about mercury that we

171
00:05:55,270 --> 00:05:53,199
will have from global

172
00:05:57,510 --> 00:05:55,280
so let me turn to the planet venus

173
00:05:59,590 --> 00:05:57,520
how many of us really think about venus

174
00:06:01,029 --> 00:05:59,600
let me stop this for a second

175
00:06:03,830 --> 00:06:01,039
here's venus in the night sky you can

176
00:06:05,350 --> 00:06:03,840
see it tonight a bright

177
00:06:06,710 --> 00:06:05,360
fourth magnitude

178
00:06:08,230 --> 00:06:06,720
feature it's the brightest thing in the

179
00:06:10,150 --> 00:06:08,240
sky other than the moon

180
00:06:12,629 --> 00:06:10,160
this is a winter shot from the last

181
00:06:14,230 --> 00:06:12,639
winter what's interesting about venus is

182
00:06:16,230 --> 00:06:14,240
a lot of astronomers are now coming to

183
00:06:18,309 --> 00:06:16,240
think as we look for other earths we

184
00:06:21,270 --> 00:06:18,319
better keep our mind's eye open to venus

185
00:06:22,870 --> 00:06:21,280
what makes venus interesting big okay

186
00:06:24,390 --> 00:06:22,880
some of us might think that rocky

187
00:06:26,309 --> 00:06:24,400
planets can only get as big as those we

188
00:06:27,670 --> 00:06:26,319

have to get too big they break apart

189
00:06:29,110 --> 00:06:27,680
they can't don't have enough internal

190
00:06:31,029 --> 00:06:29,120
strength secondly it has a huge

191
00:06:32,710 --> 00:06:31,039
atmosphere if you were standing on the

192
00:06:35,350 --> 00:06:32,720
surface of venus and i do not recommend

193
00:06:37,029 --> 00:06:35,360
that very hot if you were

194
00:06:39,670 --> 00:06:37,039
the dents of the atmosphere would be

195
00:06:41,749 --> 00:06:39,680
slightly about 10 times less dense than

196
00:06:44,309 --> 00:06:41,759
water and it's a gas

197
00:06:46,790 --> 00:06:44,319
so it's a actually a supercritical fluid

198
00:06:48,309 --> 00:06:46,800
made of carbon dioxide so imagine how

199
00:06:51,430 --> 00:06:48,319
that kind of planet works it's more like

200
00:06:53,350 --> 00:06:51,440
the gases coming out of the uncapped oil

201
00:06:54,870 --> 00:06:53,360
wells down deep in the ocean than

202
00:06:55,990 --> 00:06:54,880
anything we can imagine being here on

203
00:06:58,230 --> 00:06:56,000
planet earth

204
00:07:00,469 --> 00:06:58,240
so venus the morning star sometimes the

205
00:07:02,710 --> 00:07:00,479
night star i might add

206
00:07:05,029 --> 00:07:02,720
is really an enigma giant atmosphere

207
00:07:07,749 --> 00:07:05,039
through our eyes that's what all we see

208
00:07:09,430 --> 00:07:07,759
a fuzzball cloud decks we know those

209
00:07:12,550 --> 00:07:09,440
clouds now are partly

210
00:07:15,430 --> 00:07:12,560
comprised of of sulfuric acid droplets

211
00:07:16,469 --> 00:07:15,440
and other nasty caustic chemistry

212
00:07:18,469 --> 00:07:16,479
there have been

213
00:07:19,990 --> 00:07:18,479

more than a dozen missions by the nation

214
00:07:21,830 --> 00:07:20,000
formerly known as the soviet union to

215
00:07:24,150 --> 00:07:21,840
explore venus the united states has sent

216
00:07:25,990 --> 00:07:24,160
two missions to venus specifically one

217
00:07:27,430 --> 00:07:26,000
in the late 70s and one called magellan

218
00:07:29,589 --> 00:07:27,440
but this is the view you'd see of the

219
00:07:32,309 --> 00:07:29,599
super rotating outer atmosphere now in

220
00:07:34,150 --> 00:07:32,319
the early 90s the united states mapped

221
00:07:36,390 --> 00:07:34,160
98 of venus with a mission known as

222
00:07:38,550 --> 00:07:36,400
magellan using using something called

223
00:07:41,110 --> 00:07:38,560
synthetic aperture radar these globe

224
00:07:43,749 --> 00:07:41,120
views show the planet seen by radar at

225
00:07:45,350 --> 00:07:43,759
about the scale of or

226
00:07:47,909 --> 00:07:45,360
about the scale of the modus instrument

227
00:07:49,110 --> 00:07:47,919
on our earth observing system terra and

228
00:07:50,950 --> 00:07:49,120
here's a map

229
00:07:52,869 --> 00:07:50,960
and i'll stop this of one region of

230
00:07:54,550 --> 00:07:52,879
venus one hemisphere

231
00:07:56,710 --> 00:07:54,560
and the big features you see here are

232
00:07:59,189 --> 00:07:56,720
each the size of the united states

233
00:08:01,189 --> 00:07:59,199
they're huge this is a giant mountain

234
00:08:03,830 --> 00:08:01,199
system with rift valleys and other

235
00:08:05,909 --> 00:08:03,840
features and basically what you see here

236
00:08:07,909 --> 00:08:05,919
is color-coded topography with radar

237
00:08:10,390 --> 00:08:07,919
backscatter the problem is the scale

238
00:08:12,710 --> 00:08:10,400

you're seeing is weather satellite scale

239
00:08:14,629 --> 00:08:12,720
as planetary scientists as people we're

240
00:08:17,189 --> 00:08:14,639
used to the scale that we feel and touch

241
00:08:18,869 --> 00:08:17,199
and walk as geophysicists and others so

242
00:08:21,110 --> 00:08:18,879
the scales we have for venus aren't

243
00:08:23,029 --> 00:08:21,120
enough to tell us what made that are all

244
00:08:24,830 --> 00:08:23,039
these blue areas places that are low

245
00:08:27,350 --> 00:08:24,840
because at one point they were

246
00:08:29,189 --> 00:08:27,360
oceans wouldn't that be cool today the

247
00:08:30,790 --> 00:08:29,199
present conditions for venus would not

248
00:08:33,269 --> 00:08:30,800
support the existence of liquid water

249
00:08:34,949 --> 00:08:33,279
the average surface temperature 450

250
00:08:38,070 --> 00:08:34,959
degrees centigrade

251
00:08:41,029 --> 00:08:38,080
average surface pressure about 100 bars

252
00:08:43,110 --> 00:08:41,039
okay 10 megapascals this is not the kind

253
00:08:44,149 --> 00:08:43,120
of place you'd like to go not the place

254
00:08:46,389 --> 00:08:44,159
we're thinking about for human

255
00:08:48,310 --> 00:08:46,399
exploration however in the story of

256
00:08:49,990 --> 00:08:48,320
venus is a story that we need to be

257
00:08:51,670 --> 00:08:50,000
aware of for our own planet and this is

258
00:08:54,150 --> 00:08:51,680
very important so there's the visible

259
00:08:56,710 --> 00:08:54,160
venus big atmosphere the actual outer

260
00:08:57,829 --> 00:08:56,720
atmosphere super rotates in a period of

261
00:08:58,949 --> 00:08:57,839
two days the whole atmosphere goes

262
00:09:00,870 --> 00:08:58,959
around

263
00:09:02,389 --> 00:09:00,880

sort of like our earth's atmosphere the

264
00:09:04,790 --> 00:09:02,399
lower atmosphere of venus that you see

265
00:09:06,870 --> 00:09:04,800
here through the eyes of radar slowly

266
00:09:09,509 --> 00:09:06,880
rotates retrograde

267
00:09:11,910 --> 00:09:09,519
so in fact a year a day is longer than a

268
00:09:13,030 --> 00:09:11,920
year on venus imagine that

269
00:09:15,269 --> 00:09:13,040
why venus doesn't have natural

270
00:09:17,269 --> 00:09:15,279
satellites we don't know venus doesn't

271
00:09:19,990 --> 00:09:17,279
have an obvious giant magnetic field why

272
00:09:22,949 --> 00:09:20,000
not big hot planets tend to have those

273
00:09:24,310 --> 00:09:22,959
earth jupiter mercury what's going on we

274
00:09:27,350 --> 00:09:24,320
don't know

275
00:09:30,070 --> 00:09:27,360
what made venus climate system today

276
00:09:32,870 --> 00:09:30,080
hellishly hot caustic not friendly to

277
00:09:34,150 --> 00:09:32,880
life possibly superoxidizing what made

278
00:09:35,670 --> 00:09:34,160
it that way did was it born that way

279
00:09:37,829 --> 00:09:35,680
very unlikely it's hard for a planet to

280
00:09:40,710 --> 00:09:37,839
be born that way for many reasons so

281
00:09:42,790 --> 00:09:40,720
what made it go into a runaway situation

282
00:09:44,949 --> 00:09:42,800
again we don't know the last mission to

283
00:09:46,870 --> 00:09:44,959
venus was by the united states which