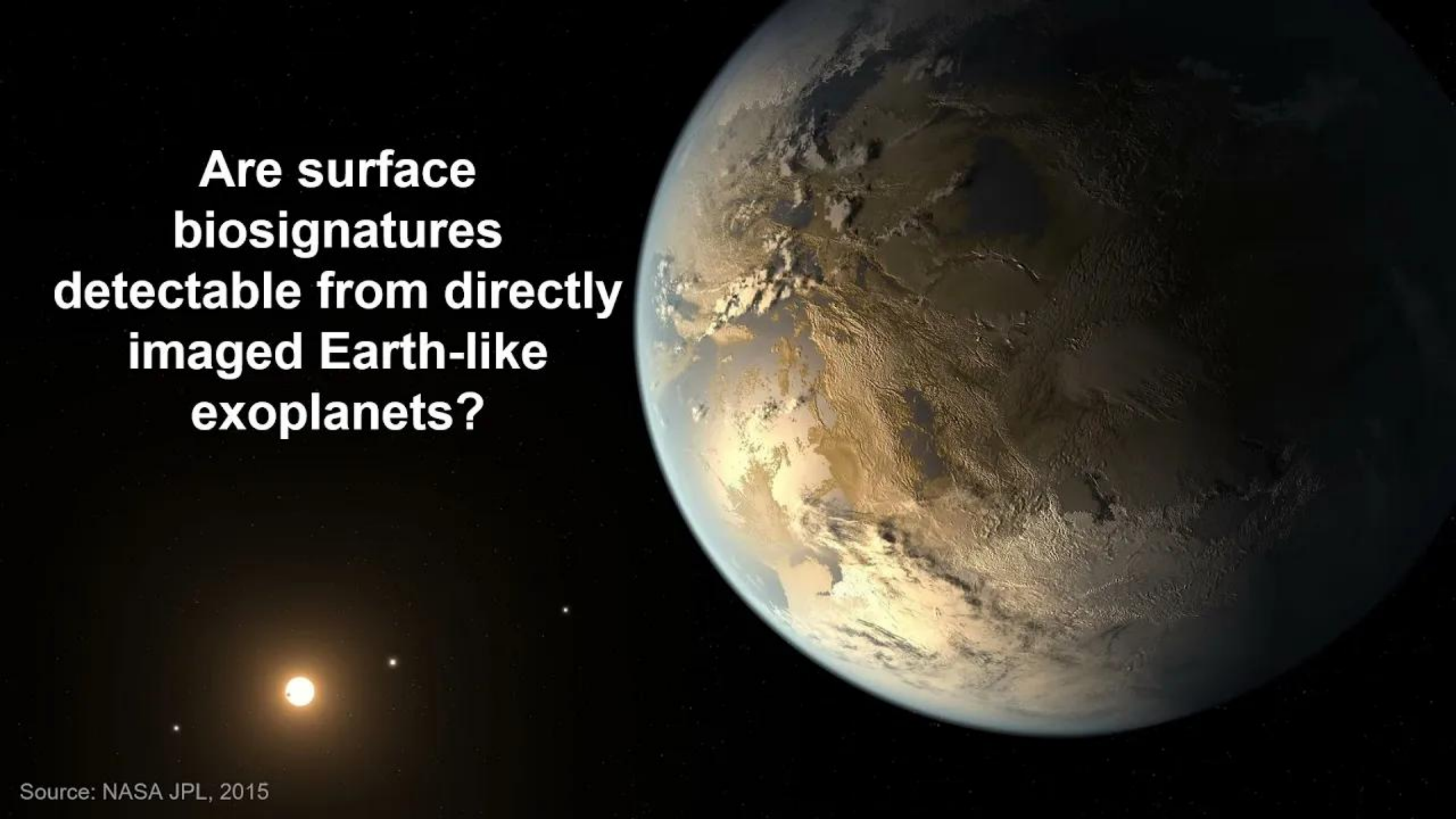

Source: NASA JPL, 2015

1
00:00:09,030 --> 00:00:06,789
hello

2
00:00:11,589 --> 00:00:09,040
i'm gabrielle jones an undergraduate

3
00:00:12,870 --> 00:00:11,599
senior at northern arizona university

4
00:00:15,190 --> 00:00:12,880
and i will be presenting on the

5
00:00:19,830 --> 00:00:15,200
detectability of service bio signatures

6
00:00:24,150 --> 00:00:21,910
previous studies have examined how

7
00:00:25,589 --> 00:00:24,160
spectral observations are influenced by

8
00:00:27,670 --> 00:00:25,599
noise sources

9
00:00:30,390 --> 00:00:27,680
and how the vegetation red edge could be

10
00:00:32,549 --> 00:00:30,400
used as a potential bile signature

11
00:00:33,510 --> 00:00:32,559
but it is currently unknown if noise

12
00:00:35,910 --> 00:00:33,520
sources

13
00:00:37,910 --> 00:00:35,920

and technological capabilities will

14
00:00:43,510 --> 00:00:37,920
allow for the detection of surface bowel

15
00:00:48,150 --> 00:00:45,670
our study modeled an exoplanet's

16
00:00:50,549 --> 00:00:48,160
atmosphere with earth-like conditions

17
00:00:52,549 --> 00:00:50,559
and computed definitive detection times

18
00:00:54,790 --> 00:00:52,559
of surface biosignatures

19
00:00:56,069 --> 00:00:54,800
using the atmospheric radiative transfer

20
00:01:01,270 --> 00:00:56,079
model smart

21
00:01:05,830 --> 00:01:04,070
so what are surface biosignatures well

22
00:01:06,550 --> 00:01:05,840
the surface biosignatures we are

23
00:01:08,230 --> 00:01:06,560
focusing on

24
00:01:10,310 --> 00:01:08,240
are biological pigments and the

25
00:01:12,789 --> 00:01:10,320
vegetation red edge

26
00:01:13,670 --> 00:01:12,799
they are features present in a reflected

27
00:01:16,870 --> 00:01:13,680
light spectrum

28
00:01:19,670 --> 00:01:16,880
that are created from living organisms

29
00:01:21,590 --> 00:01:19,680
on the figure on the right we have a

30
00:01:23,030 --> 00:01:21,600
reflected light spectrum of an orange

31
00:01:25,190 --> 00:01:23,040
microbial mat

32
00:01:27,590 --> 00:01:25,200
and here are the specific surface box

33
00:01:29,830 --> 00:01:27,600
initials we are looking for

34
00:01:34,469 --> 00:01:29,840
absorption features and the vegetation

35
00:01:39,270 --> 00:01:37,190
so what are pigments pigments are

36
00:01:41,429 --> 00:01:39,280
produced by living organisms

37
00:01:42,630 --> 00:01:41,439
that have a color resulting from

38
00:01:46,230 --> 00:01:42,640

selective color

39
00:01:48,550 --> 00:01:46,240
absorption pigment absorption features

40
00:01:50,069 --> 00:01:48,560
are troughs in the spectra of plant

41
00:01:52,389 --> 00:01:50,079
microbial life

42
00:01:53,429 --> 00:01:52,399
caused by biological pigments such as

43
00:01:56,469 --> 00:01:53,439
chlorophyll a

44
00:01:58,230 --> 00:01:56,479
and b as seen on the right

45
00:02:00,230 --> 00:01:58,240
they are created when primary

46
00:02:02,469 --> 00:02:00,240
photosynthetic molecules

47
00:02:03,670 --> 00:02:02,479
absorb energy from light as they process

48
00:02:06,709 --> 00:02:03,680
water and carbon

49
00:02:08,550 --> 00:02:06,719
into sugar and oxygen however some

50
00:02:10,389 --> 00:02:08,560
pigment absorption features

51
00:02:13,430 --> 00:02:10,399
are not dependent on life to produce

52
00:02:16,070 --> 00:02:13,440
oxygen as a byproduct of photosynthesis

53
00:02:16,710 --> 00:02:16,080
and as a result non-photosynthetic

54
00:02:21,110 --> 00:02:16,720
pigments

55
00:02:24,390 --> 00:02:23,430
the vegetation red edge is characterized

56
00:02:26,949 --> 00:02:24,400
by the region

57
00:02:28,229 --> 00:02:26,959
of rapid increase in reflectance of

58
00:02:30,710 --> 00:02:28,239
vegetation

59
00:02:31,270 --> 00:02:30,720
in the near infrared region of a

60
00:02:34,550 --> 00:02:31,280
spectrum

61
00:02:38,070 --> 00:02:34,560
around 0.6 to 0.8

62
00:02:40,390 --> 00:02:38,080
as seen in the figure here it is

63
00:02:41,990 --> 00:02:40,400

a spectral feature produced by the

64
00:02:44,309 --> 00:02:42,000
absorption of chlorophyll

65
00:02:46,309 --> 00:02:44,319
and other pigments in the ultraviolet

66
00:02:48,309 --> 00:02:46,319
invisible wavelength ranges

67
00:02:49,509 --> 00:02:48,319
and the scattering of light in the near

68
00:02:52,710 --> 00:02:49,519
infrared region

69
00:02:54,949 --> 00:02:52,720
as a result of internal cell structure

70
00:02:58,710 --> 00:02:54,959
and it is indicative of photosynthetic

71
00:03:04,630 --> 00:03:01,830
so why microbial mats microbial mats are

72
00:03:06,390 --> 00:03:04,640
composed of layers of microorganisms

73
00:03:08,550 --> 00:03:06,400
and they are the extremophiles we are

74
00:03:10,149 --> 00:03:08,560
focusing on specifically orange and

75
00:03:11,910 --> 00:03:10,159
black mats

76
00:03:14,229 --> 00:03:11,920
they are a reasonable candidate for

77
00:03:16,710 --> 00:03:14,239
detection of life on other planets

78
00:03:18,070 --> 00:03:16,720
because they are a simple light form

79
00:03:21,190 --> 00:03:18,080
making it more probable

80
00:03:22,710 --> 00:03:21,200
to exist on an exoplanet they have been

81
00:03:23,589 --> 00:03:22,720
prevalent on earth throughout its

82
00:03:25,509 --> 00:03:23,599
history

83
00:03:28,229 --> 00:03:25,519
containing some of the oldest life on

84
00:03:29,990 --> 00:03:28,239
earth and they have prominent

85
00:03:31,589 --> 00:03:30,000
vegetation red edge and pigment

86
00:03:33,589 --> 00:03:31,599
absorption features within the

87
00:03:35,430 --> 00:03:33,599
reflecting spectra

88
00:03:37,830 --> 00:03:35,440

the picture on the right showcases

89
00:03:40,149 --> 00:03:37,840
orange and black microbial mats

90
00:03:44,390 --> 00:03:40,159
in a stream bed called green creek in

91
00:03:48,229 --> 00:03:46,309
if you want to know more about microbial

92
00:03:51,110 --> 00:03:48,239
mats visit my co-author

93
00:03:53,589 --> 00:03:51,120
skylar borges talk on high resolution

94
00:03:54,309 --> 00:03:53,599
satellite mapping of microbial matte and

95
00:03:58,869 --> 00:03:54,319
moss cover

96
00:04:03,429 --> 00:04:01,750
so are surface biosignatures detectable

97
00:04:07,110 --> 00:04:03,439
from directly image earth-like

98
00:04:10,949 --> 00:04:09,350
and what kind of extremophile life can

99
00:04:13,190 --> 00:04:10,959
be detected

100
00:04:15,270 --> 00:04:13,200
to answer these questions we are using

101
00:04:16,469 --> 00:04:15,280
models to simulate the spectra of an

102
00:04:18,789 --> 00:04:16,479
exoplanet

103
00:04:19,749 --> 00:04:18,799
and test whether surface biosignatures

104
00:04:22,629 --> 00:04:19,759
are detectable

105
00:04:23,110 --> 00:04:22,639
using future and current technologies

106
00:04:26,950 --> 00:04:23,120
such as

107
00:04:29,990 --> 00:04:29,270
our first step is to create realistic

108
00:04:33,189 --> 00:04:30,000
surfaces

109
00:04:35,030 --> 00:04:33,199
of exoplanets we did this using a linear

110
00:04:37,670 --> 00:04:35,040
mixing model to mix multiple

111
00:04:41,430 --> 00:04:37,680
and members at desired percentages and

112
00:04:47,110 --> 00:04:44,790
we created various percentages of soil

113
00:04:48,870 --> 00:04:47,120

black matte and orange mat to see which

114
00:04:49,749 --> 00:04:48,880
combination would be the fastest to

115
00:04:51,590 --> 00:04:49,759
detect

116
00:04:55,110 --> 00:04:51,600
and even if some combinations are

117
00:04:58,230 --> 00:04:56,950
here are our results from our linear

118
00:05:01,990 --> 00:04:58,240
mixing model

119
00:05:04,310 --> 00:05:02,000
we mix black matte and soil with soil in

120
00:05:07,990 --> 00:05:04,320
the red

121
00:05:11,029 --> 00:05:08,000
and black 100 black matte in purple

122
00:05:17,189 --> 00:05:11,039
then we mix combinations of 25

123
00:05:21,590 --> 00:05:19,270
here are the specific surface bio

124
00:05:25,909 --> 00:05:21,600
signatures we are looking for

125
00:05:28,230 --> 00:05:25,919
the absorption pigment of chlorophyll

126
00:05:32,950 --> 00:05:28,240
and the red edge characterized by a

127
00:05:37,670 --> 00:05:35,189
we did the same combinations for orange

128
00:05:40,230 --> 00:05:37,680
matte with soil and red

129
00:05:41,590 --> 00:05:40,240
and 100 orange matte and purple with

130
00:05:45,830 --> 00:05:41,600
combinations 25

131
00:05:49,270 --> 00:05:48,150
here are the chlorophyll absorption

132
00:05:53,350 --> 00:05:49,280
pigments

133
00:05:55,749 --> 00:05:53,360
and then the steep red edge feature

134
00:05:56,710 --> 00:05:55,759
then we created mixtures of black bat

135
00:05:59,749 --> 00:05:56,720
orange matte

136
00:06:02,710 --> 00:05:59,759
and soil to represent a realistic world

137
00:06:03,909 --> 00:06:02,720
with these extremophiles here you can

138
00:06:07,350 --> 00:06:03,919

see

139
00:06:08,070 --> 00:06:07,360
the pigment features and the vegetation

140
00:06:13,510 --> 00:06:08,080
red edge

141
00:06:17,110 --> 00:06:16,070
after creating surface spectra we take

142
00:06:19,110 --> 00:06:17,120
it a step further

143
00:06:20,390 --> 00:06:19,120
and simulate an earth-like atmosphere

144
00:06:22,710 --> 00:06:20,400
using smart

145
00:06:25,110 --> 00:06:22,720
or spectral mapping atmospheric

146
00:06:27,350 --> 00:06:25,120
radiative transfer model

147
00:06:28,390 --> 00:06:27,360
and with our mixed spectrum as input

148
00:06:30,550 --> 00:06:28,400
smart will produce

149
00:06:36,390 --> 00:06:30,560
top of the atmosphere radians that we

150
00:06:41,830 --> 00:06:39,510
here are results for smart we used

151
00:06:42,550 --> 00:06:41,840
our black matte surface spectrum as

152
00:06:45,110 --> 00:06:42,560
input

153
00:06:45,590 --> 00:06:45,120
and used our output values for solar

154
00:06:48,070 --> 00:06:45,600
flux

155
00:06:49,830 --> 00:06:48,080
and radians to calculate the reflectance

156
00:06:51,670 --> 00:06:49,840
for each wavelength

157
00:06:54,150 --> 00:06:51,680
the spectrum contains surface bowel

158
00:06:54,710 --> 00:06:54,160
signatures as well as key absorption

159
00:06:59,350 --> 00:06:54,720
bands

160
00:07:02,870 --> 00:07:01,749
here is a comparative figure of our

161
00:07:05,670 --> 00:07:02,880
surface spectrum

162
00:07:09,110 --> 00:07:05,680
and smart spectrum for black matte you

163
00:07:12,150 --> 00:07:09,120

can see the vegetation red edge

164
00:07:14,950 --> 00:07:12,160
present in both spectrum and

165
00:07:17,350 --> 00:07:14,960
the pigment absorption feature in the

166
00:07:20,309 --> 00:07:17,360
surface spectrum but it is unclear

167
00:07:25,029 --> 00:07:20,319
where the the pigment absorption feature

168
00:07:28,629 --> 00:07:27,749
here are smart results for orange matte

169
00:07:31,670 --> 00:07:28,639
and here you could

170
00:07:35,029 --> 00:07:31,680
distinctly see the chlorophyll pigments

171
00:07:37,029 --> 00:07:35,039
and the vegetation red edge

172
00:07:39,110 --> 00:07:37,039
in our comparative figure we have the

173
00:07:41,670 --> 00:07:39,120
pigments and red edge again

174
00:07:45,990 --> 00:07:41,680
and that translates very well in our

175
00:07:50,309 --> 00:07:48,469
next we run those radiant spectra

176
00:07:53,110 --> 00:07:50,319
through a luvar noise model

177
00:07:53,990 --> 00:07:53,120
to output realistic detection times for

178
00:07:57,430 --> 00:07:54,000
each spectrum

179
00:07:58,070 --> 00:07:57,440
at 10 parsecs the detection times are

180
00:08:01,189 --> 00:07:58,080
calculated

181
00:08:02,629 --> 00:08:01,199
by how well the levoir noise model can

182
00:08:04,950 --> 00:08:02,639
tell the difference between

183
00:08:06,869 --> 00:08:04,960
a model with a spectrum containing

184
00:08:09,029 --> 00:08:06,879
surface biocenters

185
00:08:10,629 --> 00:08:09,039
and a model with a spectrum that has

186
00:08:13,430 --> 00:08:10,639
those features scrubbed out

187
00:08:14,230 --> 00:08:13,440
which in our case would be soil we wrote

188
00:08:17,110 --> 00:08:14,240

a script that

189
00:08:17,990 --> 00:08:17,120
individually compared our mixed spectra

190
00:08:19,830 --> 00:08:18,000
to soil

191
00:08:22,950 --> 00:08:19,840
and stored the corresponding detection

192
00:08:27,350 --> 00:08:25,670
here are our results from our noise

193
00:08:29,909 --> 00:08:27,360
detection model

194
00:08:31,110 --> 00:08:29,919
we created a table with the percentage

195
00:08:33,670 --> 00:08:31,120
abundance

196
00:08:35,670 --> 00:08:33,680
of each end member of our mixed spectrum

197
00:08:36,870 --> 00:08:35,680
and its corresponding detection time

198
00:08:38,790 --> 00:08:36,880
value

199
00:08:41,750 --> 00:08:38,800
here you can see a hundred percent black

200
00:08:45,030 --> 00:08:41,760
matte has a detection time of 12 hours

201
00:08:47,829 --> 00:08:45,040
100 orange matte has a second fastest

202
00:08:51,350 --> 00:08:47,839
detection time of 22 hours

203
00:08:54,389 --> 00:08:51,360
and our combination of 75 percent

204
00:08:59,350 --> 00:08:54,399
black matte 15 orange mat and 10

205
00:09:02,550 --> 00:08:59,360
soil has a close third of about 24 hours

206
00:09:06,070 --> 00:09:02,560
past this line is over 100 hours

207
00:09:09,990 --> 00:09:07,750
here's a plot of our percentage

208
00:09:11,990 --> 00:09:10,000
abundance of orange matte and black

209
00:09:13,750 --> 00:09:12,000
matte with the corresponding detection

210
00:09:16,389 --> 00:09:13,760
time values

211
00:09:18,470 --> 00:09:16,399
you can see a nice trend that as the

212
00:09:19,190 --> 00:09:18,480
percentage abundance of orange matte and

213
00:09:21,509 --> 00:09:19,200

black matte

214
00:09:23,590 --> 00:09:21,519
increases the detection time

215
00:09:26,389 --> 00:09:23,600
exponentially decreases

216
00:09:27,829 --> 00:09:26,399
and here are the values for 25 percent

217
00:09:34,230 --> 00:09:27,839
orange and black matte

218
00:09:36,710 --> 00:09:34,240
and 100 and as you can see

219
00:09:37,990 --> 00:09:36,720
with a higher percentage abundance

220
00:09:38,949 --> 00:09:38,000
orange matte and black matte are

221
00:09:42,070 --> 00:09:38,959
relatively

222
00:09:45,110 --> 00:09:42,080
close in detection time but the

223
00:09:47,590 --> 00:09:45,120
less abundance of each matte

224
00:09:48,829 --> 00:09:47,600
then the more separation between the

225
00:09:52,870 --> 00:09:48,839
detection times

226
00:09:57,350 --> 00:09:54,710
we found that if the percentage of

227
00:09:58,870 --> 00:09:57,360
biological was greater than or equal to

228
00:10:01,030 --> 00:09:58,880
75 percent

229
00:10:02,630 --> 00:10:01,040
then the detection time was less than

230
00:10:05,990 --> 00:10:02,640
100 hours

231
00:10:09,430 --> 00:10:06,000
and with our fastest detection time

232
00:10:11,190 --> 00:10:09,440
being blackmai at around 12 hours

233
00:10:13,590 --> 00:10:11,200
then to be able to detect life on

234
00:10:18,310 --> 00:10:13,600
another planet it is quite reasonable to

235
00:10:21,430 --> 00:10:18,320
devote tens of hours of observation time

236
00:10:23,269 --> 00:10:21,440
so why is this important understanding

237
00:10:26,310 --> 00:10:23,279
techniques for detecting life

238
00:10:26,710 --> 00:10:26,320

on an exoplanet's surface will aid in

239
00:10:28,870 --> 00:10:26,720
our

240
00:10:31,110 --> 00:10:28,880
search for life beyond earth and will

241
00:10:32,310 --> 00:10:31,120
inform future space telescope mission

242
00:10:37,750 --> 00:10:32,320
design

243
00:10:41,509 --> 00:10:40,389
moving forward we will test different a

244
00:10:43,990 --> 00:10:41,519
biologic

245
00:10:45,750 --> 00:10:44,000
spectra for our noise model to compare

246
00:10:47,509 --> 00:10:45,760
to our spectra with our surface

247
00:10:49,269 --> 00:10:47,519
biosignatures

248
00:10:51,269 --> 00:10:49,279
this is because reflectance is

249
00:10:54,069 --> 00:10:51,279
dominating detection times

250
00:10:55,110 --> 00:10:54,079
not bio signatures so to isolate the bio

251
00:10:56,870 --> 00:10:55,120
signature

252
00:10:58,550 --> 00:10:56,880
we are going to create a spectrum that

253
00:11:00,870 --> 00:10:58,560
has those features

254
00:11:04,870 --> 00:11:00,880
more specifically removed to really

255
00:11:08,150 --> 00:11:04,880
focus on detecting those signatures

256
00:11:12,150 --> 00:11:08,160
we will also run smart with clouds

257
00:11:16,230 --> 00:11:12,160
for each of our surface spectra with 25

258
00:11:19,389 --> 00:11:16,240
50 and 75 cloud coverage

259
00:11:21,910 --> 00:11:19,399
we will test other extremophiles with

260
00:11:23,670 --> 00:11:21,920
non-photosynthetic pigments and without

261
00:11:25,670 --> 00:11:23,680
the vegetation red edge

262
00:11:27,350 --> 00:11:25,680
to compare the detectability with our

263
00:11:31,350 --> 00:11:27,360

results for orange mat

264
00:11:35,670 --> 00:11:33,110
thank you so much for listening to my

265
00:11:37,190 --> 00:11:35,680
talk and please feel free to reach out