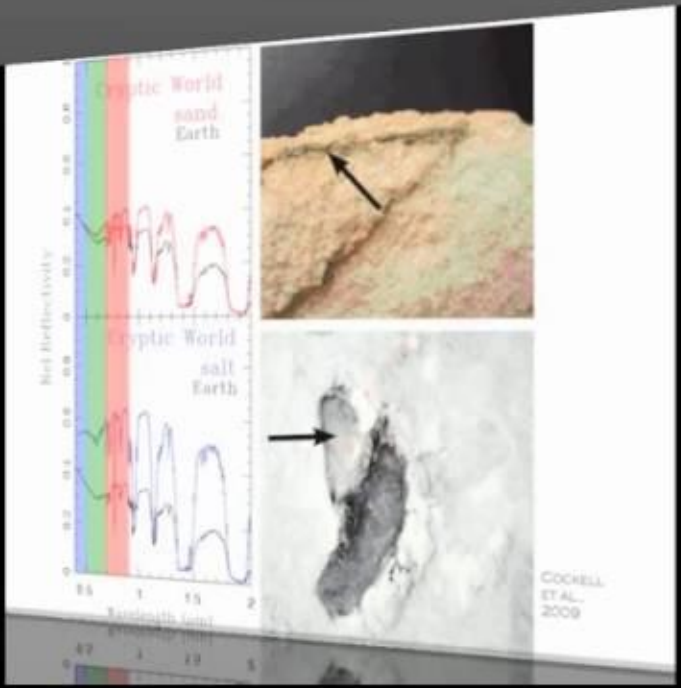
Cryptic World
sand
Earth
Cryptic World
salt
Earth
COCKELL
ET AL.
2009

1
00:00:10,930 --> 00:00:08,710
we heard a lot of talks in the morning

2
00:00:12,879 --> 00:00:10,940
which spoke about you know the number of

3
00:00:14,109 --> 00:00:12,889
exoplanets being detected recently so

4
00:00:16,779 --> 00:00:14,119
hundreds of exoplanets have been

5
00:00:19,810 --> 00:00:16,789
detected with over 2500 planet

6
00:00:22,360 --> 00:00:19,820
candidates with Kepler and Kepler is

7
00:00:26,020 --> 00:00:22,370
designed to give you the frequency of a

8
00:00:27,550 --> 00:00:26,030
particular planet around a star so what

9
00:00:46,140 --> 00:00:27,560
it does that it doesn't characterize you

10
00:00:50,310 --> 00:00:48,870
so here's a plot which tells tells you

11
00:00:52,979 --> 00:00:50,320
about the plant occurrence as a function

12
00:00:54,930 --> 00:00:52,989
of time radius and orbital period and it

13
00:00:57,450 --> 00:00:54,940

accounts for the observational biases so

14
00:00:59,190 --> 00:00:57,460
what we now know is that you do have a

15
00:01:01,799 --> 00:00:59,200
lot of large planets the size of Jupiter

16
00:01:04,290 --> 00:01:01,809
but you also have even more larger

17
00:01:06,469 --> 00:01:04,300
larger sized planets which of the size

18
00:01:08,940 --> 00:01:06,479
of Neptune and you have even more

19
00:01:11,120 --> 00:01:08,950
planets which are the size of Earth

20
00:01:14,700 --> 00:01:11,130
indicated by this color code so red here

21
00:01:17,010 --> 00:01:14,710
red here actually means you know how

22
00:01:19,499 --> 00:01:17,020
your planet frequency and green is

23
00:01:22,160 --> 00:01:19,509
towards the lower side and with

24
00:01:23,850 --> 00:01:22,170
increasing sensitivities one you know we

25
00:01:25,770 --> 00:01:23,860
foresee that there will be a lot more

26
00:01:27,810 --> 00:01:25,780
planets to us this area where you have

27
00:01:30,510 --> 00:01:27,820
higher orbital periods and lower

28
00:01:32,670 --> 00:01:30,520
planetary masses the interesting point

29
00:01:33,930 --> 00:01:32,680
here is that even with Kepler candidates

30
00:01:35,520 --> 00:01:33,940
a lot of these planets are thought to

31
00:01:39,180 --> 00:01:35,530
lie in the habitable zone of the parent

32
00:01:40,800 --> 00:01:39,190
star so which wants to be looked for

33
00:01:42,870 --> 00:01:40,810
first which wants to be characterized

34
00:01:45,719 --> 00:01:42,880
for potential habitability and see if

35
00:01:49,290 --> 00:01:45,729
they are indeed inhabited and that's

36
00:01:50,880 --> 00:01:49,300
where my talk really comes so we know

37
00:01:54,449 --> 00:01:50,890
that spectroscopy gives you detailed

38
00:01:56,669 --> 00:01:54,459

information in regard to this surface in

39
00:01:58,650 --> 00:01:56,679
the atmosphere of a planet but the

40
00:02:00,120 --> 00:01:58,660
downside is that it's time consuming and

41
00:02:03,449 --> 00:02:00,130
it's expensive

42
00:02:05,339 --> 00:02:03,459
so what I want to do here is use filter

43
00:02:08,040 --> 00:02:05,349
photometer II where it's the amount of

44
00:02:09,419 --> 00:02:08,050
flux that you you know you collect from

45
00:02:12,809 --> 00:02:09,429
the source and you split it into

46
00:02:15,150 --> 00:02:12,819
different rod bay broad bands and color

47
00:02:18,420 --> 00:02:15,160
basically means the comparison of one

48
00:02:20,699 --> 00:02:18,430
such band against the other photometric

49
00:02:23,220 --> 00:02:20,709
is a good tool to give you initial first

50
00:02:24,839 --> 00:02:23,230
order approximation we know from the

51
00:02:26,580 --> 00:02:24,849
earth that different surfaces have got

52
00:02:29,339 --> 00:02:26,590
characteristic reflectivities or albedo

53
00:02:30,570 --> 00:02:29,349
s-- what I want to see is if I can you

54
00:02:32,790 --> 00:02:30,580
know remotely characterize these

55
00:02:36,479 --> 00:02:32,800
different surfaces and if I can build a

56
00:02:38,400 --> 00:02:36,489
link to biology colors have often been

57
00:02:39,990 --> 00:02:38,410
used color color diagrams have often

58
00:02:41,580 --> 00:02:40,000
been used in galaxy astrophysics for

59
00:02:43,350 --> 00:02:41,590
instance to differentiate the different

60
00:02:45,120 --> 00:02:43,360
kinds of galaxies be it elliptical or

61
00:02:46,500 --> 00:02:45,130
spiral galaxies also in stellar

62
00:02:48,900 --> 00:02:46,510
astrophysics to differentiate the

63
00:02:50,880 --> 00:02:48,910

different types of stars one can

64
00:02:54,300 --> 00:02:50,890
actually do this for planets as well so

65
00:02:57,000 --> 00:02:54,310
here is a plot of you know the green -

66
00:02:59,309 --> 00:02:57,010
red filter against blue- green which

67
00:02:59,610 --> 00:02:59,319
Wesley draw from JPL did some time back

68
00:03:03,660 --> 00:02:59,620
and

69
00:03:05,640 --> 00:03:03,670
classify the rocky surfaces probably

70
00:03:07,740 --> 00:03:05,650
because they you know reflect dusty

71
00:03:10,470 --> 00:03:07,750
surfaces more in the near infrared bands

72
00:03:14,039 --> 00:03:10,480
they tend to group together in the red

73
00:03:16,050 --> 00:03:14,049
red plot of this color color diagram gas

74
00:03:18,240 --> 00:03:16,060
shines which have clear atmospheres tend

75
00:03:21,479 --> 00:03:18,250
to group together in the blue blue part

76
00:03:23,160 --> 00:03:21,489
of the color color diagram and then you

77
00:03:25,050 --> 00:03:23,170
have these gas giants with the cloudy

78
00:03:29,160 --> 00:03:25,060
atmosphere clouds and Hayes's which

79
00:03:30,990 --> 00:03:29,170
prevent the prevent the colors prevent

80
00:03:33,750 --> 00:03:31,000
the colors methane colors from taking

81
00:03:35,610 --> 00:03:33,760
over and they group together in this

82
00:03:37,740 --> 00:03:35,620
green green plot of this diagram and

83
00:03:39,990 --> 00:03:37,750
then you have Venus and Earth which you

84
00:03:42,420 --> 00:03:40,000
know have their own color space what I

85
00:03:44,580 --> 00:03:42,430
want to do now is focus on a new earth

86
00:03:46,440 --> 00:03:44,590
analog for the different environments no

87
00:03:49,500 --> 00:03:46,450
no no that's support extreme forms of

88
00:03:51,599 --> 00:03:49,510

life why do I consider extremophiles

89
00:03:53,940 --> 00:03:51,609
while they define they give you a wide

90
00:03:56,430 --> 00:03:53,950
definition of for life create physical

91
00:03:58,589 --> 00:03:56,440
or chemical extremes and they inhabit

92
00:04:02,069 --> 00:03:58,599
extreme niches so you can think of the

93
00:04:05,069 --> 00:04:02,079
earth as a zoo bound by a fence of

94
00:04:07,800 --> 00:04:05,079
physical and chemical extremes and you

95
00:04:10,020 --> 00:04:07,810
can mean anything inside of this region

96
00:04:12,300 --> 00:04:10,030
you could you could be fish of or

97
00:04:14,159 --> 00:04:12,310
elephants or mammals you know any sort

98
00:04:16,080 --> 00:04:14,169
of mammals but as you travels towards

99
00:04:17,849 --> 00:04:16,090
the boundaries all these complex

100
00:04:20,550 --> 00:04:17,859
organisms fall out and you have simple

101
00:04:22,860 --> 00:04:20,560
microorganisms outside of this fence of

102
00:04:24,900 --> 00:04:22,870
of course I mean a chemist biochemistry

103
00:04:30,240 --> 00:04:24,910
breaks down and you know biomolecules

104
00:04:31,980 --> 00:04:30,250
denature but at these limits so you have

105
00:04:33,990 --> 00:04:31,990
these so you could consider a limit you

106
00:04:36,510 --> 00:04:34,000
consider case where you have high ph and

107
00:04:37,830 --> 00:04:36,520
temperature like like the case of the

108
00:04:40,500 --> 00:04:37,840
octopus spring at Yellowstone National

109
00:04:42,960 --> 00:04:40,510
Park and we believe that certain

110
00:04:45,000 --> 00:04:42,970
exoplanets or rocky exoplanets outside

111
00:04:47,930 --> 00:04:45,010
of the solar system might potentially

112
00:04:51,839 --> 00:04:47,940
have these environmental conditions and

113
00:04:54,120 --> 00:04:51,849

so therefore one could use this as a

114
00:04:57,810 --> 00:04:54,130
strategy to prioritize targets you know

115
00:04:59,400 --> 00:04:57,820
when compared to the earth so these are

116
00:05:01,379 --> 00:04:59,410
different kinds of physical or chemical

117
00:05:03,689 --> 00:05:01,389
extremes that have considered and I

118
00:05:06,689 --> 00:05:03,699
don't expect you to necessarily look at

119
00:05:10,260 --> 00:05:06,699
it but let's take an example here so I

120
00:05:11,670 --> 00:05:10,270
take salinity and desiccation now most

121
00:05:13,320 --> 00:05:11,680
of the organisms that we know of on

122
00:05:14,520 --> 00:05:13,330
earth live in subsurface conditions

123
00:05:16,230 --> 00:05:14,530
there's a measure to protect themselves

124
00:05:18,240 --> 00:05:16,240
or a means to gain access to the

125
00:05:20,550 --> 00:05:18,250
required nutrients so when you look at

126
00:05:23,189 --> 00:05:20,560
these surfaces remotely you don't really

127
00:05:24,659 --> 00:05:23,199
look at Salt Lick you don't really look

128
00:05:26,520 --> 00:05:24,669
at the microorganisms but what you

129
00:05:29,159 --> 00:05:26,530
actually detect is the reflectivity or

130
00:05:32,730 --> 00:05:29,169
albedo of salt lakes or deserts in this

131
00:05:35,610 --> 00:05:32,740
case so here's an example where you have

132
00:05:38,249 --> 00:05:35,620
crypto and elliptic lichens which are

133
00:05:40,290 --> 00:05:38,259
inhabited sandstones so what you

134
00:05:43,469 --> 00:05:40,300
actually see is the reflection spectra

135
00:05:46,020 --> 00:05:43,479
of a sand covered earth and here you

136
00:05:48,029 --> 00:05:46,030
have hallow files which are living in

137
00:05:51,240 --> 00:05:48,039
salt mines and again you see the

138
00:05:52,709 --> 00:05:51,250

reflectivities of a salt cover I mean

139
00:05:54,869 --> 00:05:52,719
this is a sand covered earth and this

140
00:05:58,230 --> 00:05:54,879
one is a salt covered earth so basically

141
00:06:01,999 --> 00:05:58,240
and this is an example of you know the

142
00:06:05,999 --> 00:06:02,009
flux being bin in different colors so

143
00:06:07,920 --> 00:06:06,009
I've taken a class here from 0.94 to 0.9

144
00:06:11,850 --> 00:06:07,930
microns so basically that's four

145
00:06:13,679 --> 00:06:11,860
thousand to nine thousand microns so I

146
00:06:17,159 --> 00:06:13,689
consider different surfaces on earth

147
00:06:19,529 --> 00:06:17,169
which are you know support extreme forms

148
00:06:20,969 --> 00:06:19,539
of life I have also included

149
00:06:22,800 --> 00:06:20,979
extremophiles where the reflection

150
00:06:24,360 --> 00:06:22,810
spectra is available in literature so I

151
00:06:27,450 --> 00:06:24,370
have the reflection spectrum of great

152
00:06:29,430 --> 00:06:27,460
cold algae algae water where you have

153
00:06:32,159 --> 00:06:29,440
red algae coating rocks what 10

154
00:06:35,129 --> 00:06:32,169
centimeter below the surface of acid

155
00:06:38,490 --> 00:06:35,139
mine drainage as a test case I have this

156
00:06:40,469 --> 00:06:38,500
I have the I have the reflection spectra

157
00:06:42,329 --> 00:06:40,479
of light lichens which are desiccation

158
00:06:44,129 --> 00:06:42,339
resistant organisms and I have the

159
00:06:46,409 --> 00:06:44,139
reflection specter of bacterial mat

160
00:06:49,140 --> 00:06:46,419
which is made up of two photosynthetic

161
00:06:51,480 --> 00:06:49,150
bacteria this the sign of bacterium

162
00:06:53,249 --> 00:06:51,490
cynic office and porous and a bacterium

163
00:06:55,640 --> 00:06:53,259

flora flexus found at Yellowstone

164
00:06:58,350 --> 00:06:55,650
National Park I've also included the

165
00:07:00,600 --> 00:06:58,360
reflection specter of pls for vegetation

166
00:07:02,129 --> 00:07:00,610
red edge which is often looked at by

167
00:07:05,279 --> 00:07:02,139
different groups for remote signatures

168
00:07:08,339 --> 00:07:05,289
of life and plotting and when plotting

169
00:07:10,320 --> 00:07:08,349
and then when I the basic assumptions

170
00:07:12,059 --> 00:07:10,330
that I make is that the atmosphere is

171
00:07:13,829 --> 00:07:12,069
see-through so there's no clouds and

172
00:07:17,760 --> 00:07:13,839
Hayes's although there's a way to get

173
00:07:19,170 --> 00:07:17,770
around that i assume that the atmosphere

174
00:07:22,170 --> 00:07:19,180
does not substantially change with

175
00:07:24,389 --> 00:07:22,180
differing atmospheres and for starters i

176
00:07:26,370 --> 00:07:24,399
assume that the whole planet is covered

177
00:07:27,300 --> 00:07:26,380
by a particular surface for general

178
00:07:29,280 --> 00:07:27,310
detectability

179
00:07:30,960 --> 00:07:29,290
so because if I cannot detect it when

180
00:07:32,430 --> 00:07:30,970
it's 100% covered by a particular

181
00:07:33,810 --> 00:07:32,440
surface if I cannot characterize it

182
00:07:38,610 --> 00:07:33,820
remotely then I cannot do it for any

183
00:07:40,379 --> 00:07:38,620
other combination also a you know small

184
00:07:42,270 --> 00:07:40,389
changes in physical or chemical extremes

185
00:07:45,710 --> 00:07:42,280
can make a particular surface dominate

186
00:07:48,720 --> 00:07:45,720
and therefore this assumption holds true

187
00:07:50,909 --> 00:07:48,730
so on plotting a similar color color

188
00:07:53,240 --> 00:07:50,919

diagram but this time I'm not using

189
00:07:56,220 --> 00:07:53,250
customized filters like dropped it but

190
00:08:00,480 --> 00:07:56,230
what I did instead was use standard

191
00:08:03,120 --> 00:08:00,490
filters from 0.4 2.9 microns we see that

192
00:08:04,680 --> 00:08:03,130
these different or surfaces grouped

193
00:08:09,090 --> 00:08:04,690
together in different areas of the plot

194
00:08:11,510 --> 00:08:09,100
so you have red algae which are you know

195
00:08:14,010 --> 00:08:11,520
in Assam by drainage group together with

196
00:08:16,920 --> 00:08:14,020
this data point from acid mine drainage

197
00:08:18,000 --> 00:08:16,930
you have rocks with support and all its

198
00:08:21,210 --> 00:08:18,010
grouped together in this part of the

199
00:08:24,030 --> 00:08:21,220
spectrum what's interesting is that you

200
00:08:25,800 --> 00:08:24,040
don't have lichens bacterial mud and red

201
00:08:28,590 --> 00:08:25,810
algae you know grouped together with

202
00:08:32,219 --> 00:08:28,600
trees one possible reason is that

203
00:08:36,000 --> 00:08:32,229
lichens a composite organisms made of

204
00:08:38,579 --> 00:08:36,010
fungi and either cyanobacteria more

205
00:08:42,630 --> 00:08:38,589
green algae so the red edge for lichens

206
00:08:45,930 --> 00:08:42,640
red are sloping as as as compared to you

207
00:08:48,300 --> 00:08:45,940
know normal vegetation bacterias mat on

208
00:08:50,400 --> 00:08:48,310
the other hand they are covered by four

209
00:08:51,780 --> 00:08:50,410
ten centimeter of water and therefore

210
00:08:54,030 --> 00:08:51,790
you have strong water absorption

211
00:08:56,579 --> 00:08:54,040
features long word 0.72 microns and

212
00:08:58,770 --> 00:08:56,589
therefore the reflectivity of battir mat

213
00:09:02,130 --> 00:08:58,780

in this case differs from that of trees

214
00:09:05,280 --> 00:09:02,140
for instance the other point to notice

215
00:09:06,030 --> 00:09:05,290
that the data point for all of these

216
00:09:08,220 --> 00:09:06,040
four is synthetic

217
00:09:09,840 --> 00:09:08,230
all of these organisms having

218
00:09:12,329 --> 00:09:09,850
photosynthetic pigments is only valid

219
00:09:14,010 --> 00:09:12,339
around a sun-like star an earth-like

220
00:09:16,020 --> 00:09:14,020
planet around a sun-like star because if

221
00:09:18,660 --> 00:09:16,030
you move go towards a hotter star then

222
00:09:20,490 --> 00:09:18,670
the blackbody spectrum Peaks in the blue

223
00:09:21,990 --> 00:09:20,500
part of the spectrum and therefore trees

224
00:09:23,490 --> 00:09:22,000
will start reflecting in the blue to

225
00:09:25,170 --> 00:09:23,500
avoid overheating and therefore they

226
00:09:27,480 --> 00:09:25,180
might look blue in color if you go

227
00:09:29,070 --> 00:09:27,490
towards the coolest are the blackbody

228
00:09:30,870 --> 00:09:29,080
spectrum of the star peaks in the

229
00:09:32,760 --> 00:09:30,880
infrared bands and therefore trees

230
00:09:34,020 --> 00:09:32,770
there's very little in the visible and

231
00:09:36,090 --> 00:09:34,030
therefore trees will absorb throughout

232
00:09:38,070 --> 00:09:36,100
or any pigment chlorophyll pick if it

233
00:09:39,690 --> 00:09:38,080
has chlorophyll or like pigment will

234
00:09:42,980 --> 00:09:39,700
absorb in the entire visible band and

235
00:09:46,560 --> 00:09:42,990
therefore they might have pea black ink

236
00:09:48,840 --> 00:09:46,570
one can then basically relate these

237
00:09:51,990 --> 00:09:48,850
different surfaces to the kind of

238
00:09:54,600 --> 00:09:52,000

organisms or the kind of extremophiles

239
00:09:57,960 --> 00:09:54,610
that's that they are supporting for

240
00:09:59,730 --> 00:09:57,970
anaerobic anaerobic atmosphere which can

241
00:10:02,550 --> 00:09:59,740
help in spectroscopy because then you

242
00:10:05,190 --> 00:10:02,560
know which bands to look at also we know

243
00:10:06,389 --> 00:10:05,200
that the earth has been anaerobic for

244
00:10:08,759 --> 00:10:06,399
parts of the history of life we don't

245
00:10:10,079 --> 00:10:08,769
want present-day earth you have niches

246
00:10:12,120 --> 00:10:10,089
which support only anaerobic

247
00:10:14,130 --> 00:10:12,130
environments and therefore you can build

248
00:10:17,280 --> 00:10:14,140
a link with aerobic and what organisms

249
00:10:22,560 --> 00:10:17,290
an anaerobic organisms with the

250
00:10:24,690 --> 00:10:22,570
environment that it its inhabiting but

251
00:10:27,600 --> 00:10:24,700
the whole point of this talk and the

252
00:10:30,780 --> 00:10:27,610
work was to find exoplanet candidates

253
00:10:32,850 --> 00:10:30,790
for prioritization I want to know which

254
00:10:34,500 --> 00:10:32,860
earth-like planets to look for first

255
00:10:37,800 --> 00:10:34,510
which wants to characterize because

256
00:10:41,340 --> 00:10:37,810
remember that spectroscopy so future

257
00:10:44,040 --> 00:10:41,350
missions likes like for instance echo or

258
00:10:45,660 --> 00:10:44,050
or any any other characterizing mission

259
00:10:47,400 --> 00:10:45,670
will have only a handful of planets to

260
00:10:49,650 --> 00:10:47,410
look at first which ones which should we

261
00:10:52,710 --> 00:10:49,660
look at Kepler has detected hundreds and

262
00:10:54,329 --> 00:10:52,720
thousands of planets tests the NASA

263
00:10:55,880 --> 00:10:54,339

based mission will also do that but

264
00:10:58,290 --> 00:10:55,890
which one should we look for first

265
00:11:00,420 --> 00:10:58,300
so I started considering mixed surfaces

266
00:11:03,210 --> 00:11:00,430
but following my initial assumption of a

267
00:11:05,819 --> 00:11:03,220
particular surface dominating I kept one

268
00:11:08,009 --> 00:11:05,829
surface as the dominating surface and

269
00:11:09,300 --> 00:11:08,019
kept increasing the surface content for

270
00:11:11,790 --> 00:11:09,310
water because water as we know is

271
00:11:14,069 --> 00:11:11,800
required for habitability so I think I

272
00:11:17,090 --> 00:11:14,079
took the whole parameter space from 0 to

273
00:11:20,189 --> 00:11:17,100
100 for water and what we see is that

274
00:11:21,569 --> 00:11:20,199
even when we increase the water and when

275
00:11:23,069 --> 00:11:21,579
we consider in these mixed surfaces

276
00:11:25,579 --> 00:11:23,079
although you have degenerate surfaces

277
00:11:28,590 --> 00:11:25,589
here they all fall in this tight band

278
00:11:31,680 --> 00:11:28,600
which I call region one defined as

279
00:11:34,100 --> 00:11:31,690
extreme Earth's when I increase when I

280
00:11:36,630 --> 00:11:34,110
consider non extreme forms of life these

281
00:11:40,920 --> 00:11:36,640
this region expands to reaching to which

282
00:11:43,079 --> 00:11:40,930
I call then this habitable region so

283
00:11:44,850 --> 00:11:43,089
what do we have now so if I have two

284
00:11:47,519 --> 00:11:44,860
data points which are located here and

285
00:11:49,410 --> 00:11:47,529
here although this point is interesting

286
00:11:52,290 --> 00:11:49,420
we have no reference to compare with

287
00:11:53,699 --> 00:11:52,300
that to on earth you know so therefore

288
00:11:55,079 --> 00:11:53,709

this data point will get a higher

289
00:11:57,689 --> 00:11:55,089
priority for follow-up

290
00:11:59,790 --> 00:11:57,699
spectroscopy but if you have two data

291
00:12:01,769 --> 00:11:59,800
points over here and here then higher

292
00:12:04,079 --> 00:12:01,779
priority will be given to any data point

293
00:12:05,670 --> 00:12:04,089
which is towards the lower left on left

294
00:12:08,189 --> 00:12:05,680
lower left corner of the plot because

295
00:12:10,519 --> 00:12:08,199
that would indicate higher free liquid

296
00:12:13,259 --> 00:12:10,529
water on the surface because remember

297
00:12:23,129 --> 00:12:13,269
liquid water falls towards the bottom of

298
00:12:26,009 --> 00:12:23,139
the panel and yeah so basically colors

299
00:12:29,040 --> 00:12:26,019
are useful in priorities prioritizing

300
00:12:30,929 --> 00:12:29,050
targets they help you build a link

301
00:12:33,960 --> 00:12:30,939
between environmental conditions and

302
00:12:38,280 --> 00:12:33,970
life they can also be used although I've

303
00:12:39,989 --> 00:12:38,290
used organisms which are thriving in a

304
00:12:41,939 --> 00:12:39,999
particular physical or chemical extreme

305
00:12:44,280 --> 00:12:41,949
one can use this for poly extremophiles

306
00:12:46,499 --> 00:12:44,290
which can live in multiple environmental

307
00:12:49,049 --> 00:12:46,509
extremes or any new organisms found in

308
00:12:50,879 --> 00:12:49,059
you niches the important thing to

309
00:12:53,009 --> 00:12:50,889
remember to note here is that this does

310
00:12:54,989 --> 00:12:53,019
not tell you whether there is life or

311
00:12:57,689 --> 00:12:54,999
not what it tells you is that a

312
00:13:00,480 --> 00:12:57,699
particular candidate or a planet is it

313
00:13:04,379 --> 00:13:00,490

useful for following up and therefore

314
00:13:07,410 --> 00:13:04,389
spectroscopy with this method is useful

315
00:13:08,970 --> 00:13:07,420
for determining the overall habitability

316
00:13:11,220 --> 00:13:08,980
or potential habitability of the planet

317
00:13:33,950 --> 00:13:11,230
and also see if the planet is indeed

318
00:13:38,910 --> 00:13:36,990
yeah the question is if I have thought

319
00:13:40,260 --> 00:13:38,920
of including clouds in Hayes's in my

320
00:13:43,380 --> 00:13:40,270
model yes that's something I've been

321
00:13:45,060 --> 00:13:43,390
currently working on so I spoke about I

322
00:13:46,860 --> 00:13:45,070
said that it's difficult if there are

323
00:13:50,700 --> 00:13:46,870
clouds and haze is in the model so

324
00:13:53,340 --> 00:13:50,710
basically if that problem only arises if

325
00:13:54,960 --> 00:13:53,350
there's 100% cloud coverage you know

326
00:13:56,280 --> 00:13:54,970
then you cannot really see anything but

327
00:13:59,190 --> 00:13:56,290
even if you don't even if you have say

328
00:14:00,329 --> 00:13:59,200
90% clouds there's a research group in

329
00:14:02,550 --> 00:14:00,339
in Spain

330
00:14:05,519 --> 00:14:02,560
enric polish group which has recently

331
00:14:07,079 --> 00:14:05,529
showed that if you get a high enough

332
00:14:09,090 --> 00:14:07,089
signal to noise ratio every one

333
00:14:11,760 --> 00:14:09,100
twentieth of the planets rotation if you

334
00:14:13,380 --> 00:14:11,770
have say high time resolution and you

335
00:14:14,579 --> 00:14:13,390
have high enough signal to noise ratio

336
00:14:16,200 --> 00:14:14,589
every one point here that plants

337
00:14:19,050 --> 00:14:16,210
rotation one can basically integrate all

338
00:14:20,700 --> 00:14:19,060

these signals and construct the surfaces

339
00:14:24,690 --> 00:14:20,710
together using principal component

340
00:14:26,310 --> 00:14:24,700
analysis so it's possible yeah so

341
00:14:29,790 --> 00:14:26,320
basically if you use clouds your

342
00:14:31,650 --> 00:14:29,800
reflectivities would increase but you

343
00:14:33,810 --> 00:14:31,660
know if you have you can you have these

344
00:14:35,519 --> 00:14:33,820
windows and therefore if you add them