
AbSciCon
2017
MESA, ARIZONA

1
00:00:12,250 --> 00:00:06,150
you

2
00:00:19,210 --> 00:00:14,220
[Music]

3
00:00:21,790 --> 00:00:19,220
hi everyone so what I thought was I

4
00:00:24,999 --> 00:00:21,800
thought I'd use some of the earlier

5
00:00:27,280 --> 00:00:25,009
talks and and the information and the

6
00:00:29,680 --> 00:00:27,290
pigments and the evolution of those and

7
00:00:31,029 --> 00:00:29,690
see sort of put it in a context as far

8
00:00:33,130 --> 00:00:31,039
as like the planets are concerned to see

9
00:00:34,720 --> 00:00:33,140
if we could detect these signatures

10
00:00:37,330 --> 00:00:34,730
remotely and what is what are the

11
00:00:41,229 --> 00:00:37,340
challenges in terms of wavelengths we

12
00:00:43,570 --> 00:00:41,239
would need to sort of prioritize or you

13
00:00:46,180 --> 00:00:43,580

know taking into account under the

14
00:00:48,130 --> 00:00:46,190
atmosphere and the cloud effects so I'll

15
00:00:50,200 --> 00:00:48,140
start with this

16
00:00:52,479 --> 00:00:50,210
this plot that I came across a couple of

17
00:00:55,959 --> 00:00:52,489
weeks ago which is based on the Trappist

18
00:00:59,440 --> 00:00:55,969
APIs system you know it was detected a

19
00:01:01,900 --> 00:00:59,450
couple of months ago the star being

20
00:01:03,580 --> 00:01:01,910
about 40 light years away and three

21
00:01:06,490 --> 00:01:03,590
planets happened to lie in the so-called

22
00:01:09,100 --> 00:01:06,500
habitable zone and what we see here are

23
00:01:15,490 --> 00:01:09,110
density curves from Zenit au which shows

24
00:01:17,170 --> 00:01:15,500
you know which shows what if a plant is

25
00:01:20,410 --> 00:01:17,180
made up of different kinds of materials

26
00:01:22,570 --> 00:01:20,420
like a pure water world of pure iron

27
00:01:24,280 --> 00:01:22,580
world you know where would where with

28
00:01:26,170 --> 00:01:24,290
the planets form fall in terms of

29
00:01:28,030 --> 00:01:26,180
density curves now what we see already

30
00:01:31,960 --> 00:01:28,040
here is although these are initial

31
00:01:34,570 --> 00:01:31,970
estimates recent work carried out an

32
00:01:37,300 --> 00:01:34,580
odds on this front show that the

33
00:01:43,120 --> 00:01:40,810
dat could be on the surface so I was

34
00:01:47,440 --> 00:01:43,130
curious in terms of what if we detect

35
00:01:49,810 --> 00:01:47,450
what what it was can we have can these

36
00:01:52,359 --> 00:01:49,820
planets be potentially habitable and if

37
00:01:53,340 --> 00:01:52,369
so is the case can we detect differences

38
00:01:55,929 --> 00:01:53,350

between

39
00:01:58,300 --> 00:01:55,939
purely water world and a water world

40
00:02:00,550 --> 00:01:58,310
that has some sort of biota on it be it

41
00:02:02,770 --> 00:02:00,560
you know photosynthetic organisms like

42
00:02:03,940 --> 00:02:02,780
algae for instance or and can we

43
00:02:07,600 --> 00:02:03,950
distinguish between these different

44
00:02:09,759 --> 00:02:07,610
algal communities algae are known to

45
00:02:11,410 --> 00:02:09,769
form large biological structures on

46
00:02:13,900 --> 00:02:11,420
earth and can be easily detected with

47
00:02:16,750 --> 00:02:13,910
high resolution spacecraft images and

48
00:02:19,870 --> 00:02:16,760
and they contain a diversity of pigments

49
00:02:21,460 --> 00:02:19,880
so most of the pigments that that she'll

50
00:02:24,670 --> 00:02:21,470
mentioned a nikkie mentioned in the

51
00:02:25,550 --> 00:02:24,680
earlier talks these these are very

52
00:02:27,680 --> 00:02:25,560
commonly

53
00:02:29,510 --> 00:02:27,690
then photosynthetic algae and they

54
00:02:31,370 --> 00:02:29,520
usually carry out oxygenic

55
00:02:33,440 --> 00:02:31,380
photosynthesis so you may not see

56
00:02:35,780 --> 00:02:33,450
pigments like bacteria chlorophyll which

57
00:02:37,190 --> 00:02:35,790
go out put in the infrared but you see a

58
00:02:39,199 --> 00:02:37,200
range of chlorophyll pigments and

59
00:02:42,320 --> 00:02:39,209
accessory pigments which I will come to

60
00:02:43,970 --> 00:02:42,330
in a bit so one of the things we did a

61
00:02:46,759 --> 00:02:43,980
couple of years ago and if you haven't

62
00:02:49,790 --> 00:02:46,769
come across some of this work is we sort

63
00:02:52,400 --> 00:02:49,800

of isolated a range of organisms both

64
00:02:54,380 --> 00:02:52,410
photosynthetic and non-photosynthetic

65
00:02:55,729 --> 00:02:54,390
organisms to see how the spectral

66
00:02:58,250 --> 00:02:55,739
signatures for a diversity of

67
00:03:00,470 --> 00:02:58,260
pigmentation types would look like not

68
00:03:02,900 --> 00:03:00,480
just for organisms that live in extremes

69
00:03:04,820 --> 00:03:02,910
but for organisms that encompass both

70
00:03:10,210 --> 00:03:04,830
the extreme and the niche environments

71
00:03:12,680 --> 00:03:10,220
and and these can be accessed at that

72
00:03:15,500 --> 00:03:12,690
website here it's a hosted at Cornell

73
00:03:16,820 --> 00:03:15,510
but these are hemispherical measurements

74
00:03:18,949 --> 00:03:16,830
which means that they sort of give you

75
00:03:22,460 --> 00:03:18,959
the disc integrated reflecting spectrum

76
00:03:25,580 --> 00:03:22,470
for an organism and the whole spectrum

77
00:03:30,009 --> 00:03:25,590
goes from around 0.35 micron all the way

78
00:03:36,170 --> 00:03:33,229
so what we did here was we measured

79
00:03:39,259 --> 00:03:36,180
about 137 organisms containing the range

80
00:03:46,340 --> 00:03:39,269
of pigments but I'd like to use a subset

81
00:03:51,050 --> 00:03:46,350
of those for this particular talk so I

82
00:03:52,849 --> 00:03:51,060
considered about you know about 16 to 16

83
00:03:54,650 --> 00:03:52,859
algal communities containing a diversity

84
00:04:00,940 --> 00:03:54,660
of pigmentation and what you can see

85
00:04:05,900 --> 00:04:03,620
polyphyletic in a sense that you can

86
00:04:09,830 --> 00:04:05,910
it's distinct it's challenging to put a

87
00:04:11,780 --> 00:04:09,840
particular alpha microorganism or algae

88
00:04:14,420 --> 00:04:11,790

outer organism in a particular I'll go

89
00:04:17,330 --> 00:04:14,430
band based on phylogenetic you could

90
00:04:20,900 --> 00:04:17,340
have different classes of organisms in

91
00:04:23,690 --> 00:04:20,910
the same algo algorithm division or you

92
00:04:25,370 --> 00:04:23,700
could have organisms which belong to the

93
00:04:28,700 --> 00:04:25,380
same phylogeny that belong to different

94
00:04:30,200 --> 00:04:28,710
algae so usually algae are sort of

95
00:04:34,399 --> 00:04:30,210
distinguished based on their

96
00:04:36,710 --> 00:04:34,409
pigmentation types and the the range of

97
00:04:38,269 --> 00:04:36,720
pigments that these organisms have is

98
00:04:40,099 --> 00:04:38,279
either evolution specific

99
00:04:44,089 --> 00:04:40,109
or depends on the radiation that is

100
00:04:46,609 --> 00:04:44,099
available to these organisms the other

101
00:04:48,049 --> 00:04:46,619
thing is that the absorption of these

102
00:04:50,239 --> 00:04:48,059
pigments depends on the in which

103
00:04:52,009 --> 00:04:50,249
individual pigment as well as the

104
00:04:54,199 --> 00:04:52,019
chemical environment limit in which it's

105
00:04:56,299 --> 00:04:54,209
found so you might have the same pigment

106
00:04:58,429 --> 00:04:56,309
but it might be in different chemical

107
00:05:02,559 --> 00:04:58,439
environments so the absorption shot of

108
00:05:08,659 --> 00:05:06,199
so here's a plot between reflectance and

109
00:05:10,519 --> 00:05:08,669
wavelength in the to Mike from point

110
00:05:13,249 --> 00:05:10,529
four all the way to two microns and what

111
00:05:18,199 --> 00:05:13,259
we see here is that a good example would

112
00:05:20,779 --> 00:05:18,209
be this diagram the plot in the towards

113
00:05:22,579 --> 00:05:20,789

the bottom the last three ones and all

114
00:05:25,699 --> 00:05:22,589
of them are red algae you know it looks

115
00:05:27,619 --> 00:05:25,709
green pink and red but they have the

116
00:05:30,469 --> 00:05:27,629
same pigments the difference is that

117
00:05:32,629 --> 00:05:30,479
usually for energy for instance you know

118
00:05:35,269 --> 00:05:32,639
psycrow editor in a psycho pilots

119
00:05:37,279 --> 00:05:35,279
phycocyanin these are on top of the

120
00:05:38,929 --> 00:05:37,289
chlorophyll pigments and the abundance

121
00:05:41,389 --> 00:05:38,939
of those pigments these accessory

122
00:05:42,829 --> 00:05:41,399
pigments so they help and you know they

123
00:05:45,109 --> 00:05:42,839
help in photosynthesis but they also

124
00:05:47,359 --> 00:05:45,119
help in oxidative damage prevention and

125
00:05:49,129 --> 00:05:47,369
the abundance of that will decide what

126
00:05:51,169 --> 00:05:49,139
the pig color would look like if there's

127
00:05:52,789 --> 00:05:51,179
a lot of those accessory pigments then

128
00:05:56,179 --> 00:05:52,799
the algae tend to look red in color

129
00:05:57,889 --> 00:05:56,189
where the lack of them would give you a

130
00:06:00,649 --> 00:05:57,899
greenish color then because then that

131
00:06:04,119 --> 00:06:00,659
the chlorophyll pigments show up what is

132
00:06:07,969 --> 00:06:04,129
what you also see is that most of the

133
00:06:09,859 --> 00:06:07,979
organisms look quite similar in the

134
00:06:11,449 --> 00:06:09,869
inferred near-infrared vance because

135
00:06:13,069 --> 00:06:11,459
most of them have similar what

136
00:06:15,769 --> 00:06:13,079
absorption bands which is probably due

137
00:06:18,199 --> 00:06:15,779
to the water of hydration of both in its

138
00:06:21,109 --> 00:06:18,209

free and bound States but if you go to

139
00:06:23,109 --> 00:06:21,119
the visible band then that's when you

140
00:06:29,610 --> 00:06:23,119
see differentiate differences in these

141
00:06:34,480 --> 00:06:32,500
what I'd like to do then is we took some

142
00:06:38,560 --> 00:06:34,490
of these organisms and we started we

143
00:06:40,629 --> 00:06:38,570
reused a exoplanet atmospheric code

144
00:06:42,700 --> 00:06:40,639
called eggs a prime which is a

145
00:06:45,129 --> 00:06:42,710
one-dimensional coupled radiative

146
00:06:49,330 --> 00:06:45,139
transfer code which takes into account

147
00:06:51,370 --> 00:06:49,340
the stellar and planetary of parameters

148
00:06:54,100 --> 00:06:51,380
and calculates the reflection

149
00:06:56,950 --> 00:06:54,110
transmission and emission spectrum for a

150
00:06:58,300 --> 00:06:56,960
planet the code in turn consists of a

151
00:07:00,370 --> 00:06:58,310
one-dimensional climate code

152
00:07:02,170 --> 00:07:00,380
one-dimensional for a chemistry code and

153
00:07:04,690 --> 00:07:02,180
one-dimensional radiative cap transfer

154
00:07:06,879 --> 00:07:04,700
code what we started off initially doing

155
00:07:10,240 --> 00:07:06,889
is like the previous talk that Jack

156
00:07:11,980 --> 00:07:10,250
mentioned we we covered we covered an

157
00:07:14,620 --> 00:07:11,990
entire surface with a particular

158
00:07:15,610 --> 00:07:14,630
organism to to get a sense of the

159
00:07:18,760 --> 00:07:15,620
general detectability

160
00:07:20,409 --> 00:07:18,770
and the surface signal strength so we

161
00:07:22,900 --> 00:07:20,419
know what what's the sense that its

162
00:07:25,690 --> 00:07:22,910
maximum peak and then we started

163
00:07:28,409 --> 00:07:25,700

incorporating other other surfaces so we

164
00:07:30,670 --> 00:07:28,419
tried including we play started

165
00:07:33,040 --> 00:07:30,680
exploring the parameter space for water

166
00:07:36,190 --> 00:07:33,050
then to see how these signatures would

167
00:07:38,469 --> 00:07:36,200
change if you were to have a lesser

168
00:07:40,210 --> 00:07:38,479
faction of the biota and compared to the

169
00:07:43,000 --> 00:07:40,220
water fraction that's covering in the

170
00:07:45,310 --> 00:07:43,010
ocean we also play around with the

171
00:07:49,839 --> 00:07:45,320
parameterization for clouds to see how

172
00:07:55,350 --> 00:07:49,849
clouds would help or you sort of hide

173
00:07:59,020 --> 00:07:55,360
these features from remote detection and

174
00:08:02,140 --> 00:07:59,030
so here's a plot of it looks complicated

175
00:08:04,960 --> 00:08:02,150
were to make it a little further in

176
00:08:07,360 --> 00:08:04,970
Avoyelles so basically in the infrared

177
00:08:09,010 --> 00:08:07,370
portion so if you look at 1.0 micron to

178
00:08:11,020 --> 00:08:09,020
2 microns all the features look at the

179
00:08:13,240 --> 00:08:11,030
same and these are primarily because of

180
00:08:14,920 --> 00:08:13,250
these water absorption bands and the

181
00:08:16,659 --> 00:08:14,930
atmospheric effects with our next scent

182
00:08:18,300 --> 00:08:16,669
and so it's very difficult to probe

183
00:08:21,129 --> 00:08:18,310
through the surface in these conditions

184
00:08:24,610 --> 00:08:21,139
so if I look in the visible band then

185
00:08:26,770 --> 00:08:24,620
that's when surface features start to

186
00:08:28,450 --> 00:08:26,780
sort of come up so here we have in the

187
00:08:30,180 --> 00:08:28,460
blue color like right at the bottom

188
00:08:32,829 --> 00:08:30,190

that's the complaint that's 100%

189
00:08:34,480 --> 00:08:32,839
completely covered by oceans and then I

190
00:08:36,219 --> 00:08:34,490
started playing around with the surfaces

191
00:08:37,850 --> 00:08:36,229
so I started increasing the surface

192
00:08:40,490 --> 00:08:37,860
coverage so 10

193
00:08:42,140 --> 00:08:40,500
thirty fifty seventy and hundred and you

194
00:08:43,940 --> 00:08:42,150
see that obviously four hundred you see

195
00:08:46,340 --> 00:08:43,950
more of the pigment character pigment

196
00:08:49,160 --> 00:08:46,350
absorption and the pigment properties as

197
00:08:50,600 --> 00:08:49,170
opposed to having some somewhere between

198
00:08:53,030 --> 00:08:50,610
you know some something like ten percent

199
00:08:55,310 --> 00:08:53,040
would where you have a 10 percent biota

200
00:08:57,050 --> 00:08:55,320
and a 90 percent water surface detection

201
00:09:02,150 --> 00:08:57,060
of these pigments becomes extremely

202
00:09:04,370 --> 00:09:02,160
challenging it if not impossible the

203
00:09:06,230 --> 00:09:04,380
other thing I did then was I tried to

204
00:09:08,150 --> 00:09:06,240
play around with the with a cloud

205
00:09:10,790 --> 00:09:08,160
fashion and again the same thing happens

206
00:09:13,190 --> 00:09:10,800
is before clouds sort of a have a very

207
00:09:14,660 --> 00:09:13,200
high reflectivity and clouds though

208
00:09:17,560 --> 00:09:14,670
itself have close to 90 percent

209
00:09:19,880 --> 00:09:17,570
reflective II and they try to this they

210
00:09:23,030 --> 00:09:19,890
hide all the surface atmospheric

211
00:09:26,030 --> 00:09:23,040
features and and that's what we see here

212
00:09:28,790 --> 00:09:26,040
but if I go into visible again and if I

213
00:09:30,680 --> 00:09:28,800

go from you know a completely 0 passing

214
00:09:32,810 --> 00:09:30,690
cloud coverage to a 90 percent cloud

215
00:09:35,120 --> 00:09:32,820
coverage I see that all the surface

216
00:09:37,670 --> 00:09:35,130
surface features tend to sort of

217
00:09:39,440 --> 00:09:37,680
disappear at about 60 to 70 percent

218
00:09:41,930 --> 00:09:39,450
clouds fraction so we want something

219
00:09:44,540 --> 00:09:41,940
that we need clouds we do need clouds

220
00:09:45,920 --> 00:09:44,550
because that helps in raising the signal

221
00:09:47,510 --> 00:09:45,930
so it's easy to detect because if you

222
00:09:49,310 --> 00:09:47,520
have a completely ocean world like the

223
00:09:53,060 --> 00:09:49,320
one in the blue then you're getting an

224
00:09:55,130 --> 00:09:53,070
albedo of close to 0.1 which are 0.04 in

225
00:09:56,150 --> 00:09:55,140
fact which is that which means that if

226
00:09:57,740 --> 00:09:56,160
you're looking at the planet the planet

227
00:09:59,180 --> 00:09:57,750
is going to look very very dark so

228
00:10:02,780 --> 00:09:59,190
you're not going to get any signal you

229
00:10:04,730 --> 00:10:02,790
want these photons from the planet so so

230
00:10:06,530 --> 00:10:04,740
you know these clouds will help get you

231
00:10:07,810 --> 00:10:06,540
an increase in signal but at the same

232
00:10:12,340 --> 00:10:07,820
time you don't want them to be

233
00:10:16,310 --> 00:10:12,350
overshadowing the complete atmosphere so

234
00:10:19,580 --> 00:10:16,320
so so mix somewhere between you know 40

235
00:10:22,640 --> 00:10:19,590
to 60% clouds 60% looks at the optimum

236
00:10:27,440 --> 00:10:22,650
band for these surface feature detection

237
00:10:29,620 --> 00:10:27,450
and yeah so I'll stop there by saying

238
00:10:32,120 --> 00:10:29,630

that you know surface features look a

239
00:10:35,120 --> 00:10:32,130
best detectable in the point four point

240
00:10:36,650 --> 00:10:35,130
eight micron band now with with the

241
00:10:38,690 --> 00:10:36,660
surface coverage of greater than 30

242
00:10:43,250 --> 00:10:38,700
percent in a cloud fashion of less than

243
00:10:45,860 --> 00:10:43,260
sixty percent the new future instruments

244
00:10:48,140 --> 00:10:45,870
like the GMT Seacliff which is onboard

245
00:10:50,810 --> 00:10:48,150
its respected graph on both the GMT that

246
00:10:52,910 --> 00:10:50,820
do to come on and 2024

247
00:10:55,370 --> 00:10:52,920
including other space missions like w

248
00:10:57,890 --> 00:10:55,380
first look war which probably will have

249
00:10:59,570 --> 00:10:57,900
these capabilities and for detecting

250
00:11:07,880 --> 00:10:59,580
such signatures for habitability and

251
00:11:16,819 --> 00:11:07,890
life thank you I think we have time for

252
00:11:21,889 --> 00:11:19,609
I really held her like blank Institute

253
00:11:24,229 --> 00:11:21,899
the solar system research in getting

254
00:11:28,910 --> 00:11:24,239
Germany my question I'm a bit confused

255
00:11:30,499 --> 00:11:28,920
about the aspect of cloud coverage I

256
00:11:32,419 --> 00:11:30,509
would guess that if you have more clouds

257
00:11:34,549 --> 00:11:32,429
than what you of course you get more

258
00:11:36,350 --> 00:11:34,559
photons but they wouldn't have anything

259
00:11:38,119 --> 00:11:36,360
to do with the bacteria that are below

260
00:11:40,429 --> 00:11:38,129
the clouds because they are just

261
00:11:43,429 --> 00:11:40,439
reflected stellar light so could you

262
00:11:45,739 --> 00:11:43,439
walk me through as to why your signal of

263
00:11:47,569 --> 00:11:45,749

the bacteria around the surface should

264
00:11:50,269 --> 00:11:47,579
actually increase if you have more cloud

265
00:11:53,509 --> 00:11:50,279
coverage now the cloud cover is I think

266
00:11:56,179 --> 00:11:53,519
a cloud coverage which increases because

267
00:11:58,629 --> 00:11:56,189
the clouds reflect a lot more light the

268
00:12:00,710 --> 00:11:58,639
bacteria would decrease the signal

269
00:12:02,900 --> 00:12:00,720
because the albedo the reflectance

270
00:12:05,090 --> 00:12:02,910
factor for bacteria let much lower than

271
00:12:06,319 --> 00:12:05,100
that so it'd be net integrated would be

272
00:12:09,410 --> 00:12:06,329
less than what you would have if you

273
00:12:13,970 --> 00:12:09,420
were to have this clouds by itself so

274
00:12:16,609 --> 00:12:13,980
that make sense Shawn Tomiko golden NASA

275
00:12:18,259 --> 00:12:16,619
Goddard so in theory if I'm interested

276
00:12:19,660 --> 00:12:18,269
in building a space telescope to look

277
00:12:22,039 --> 00:12:19,670
for signs of life

278
00:12:23,629 --> 00:12:22,049
would you have any advice in terms of

279
00:12:26,150 --> 00:12:23,639
not just the wavelengths but the

280
00:12:28,129 --> 00:12:26,160
spectral resolution yes we played around

281
00:12:30,379 --> 00:12:28,139
we we calculated those as well

282
00:12:32,929 --> 00:12:30,389
we tried we've been calculating the

283
00:12:37,069 --> 00:12:32,939
spectral resolution for JWST in the eye

284
00:12:38,539 --> 00:12:37,079
no JW starts in point six and it they it

285
00:12:43,699 --> 00:12:38,549
claims to have a spectral resolution of

286
00:12:46,600 --> 00:12:43,709
150 for the visible and 150 was we could

287
00:12:49,970 --> 00:12:46,610
still see significant pigment absorption

288
00:12:52,069 --> 00:12:49,980

lines in the visible bands so I would

289
00:12:54,859 --> 00:12:52,079
guess 150 is good enough as well so 150

290
00:12:56,059 --> 00:12:54,869
sufficient but but you don't know what

291
00:12:58,369 --> 00:12:56,069
the what the cutoff would be for

292
00:13:02,150 --> 00:12:58,379
detecting or not is that yes so I met

293
00:13:05,600 --> 00:13:02,160
with the MRSA days look Lopez at the CFA

294
00:13:08,419 --> 00:13:05,610
in San Francisco for the breakthrough

295
00:13:10,909 --> 00:13:08,429
meeting just this last week I was with

296
00:13:12,919 --> 00:13:10,919
Jack at fantastic and I spoke to her

297
00:13:14,659 --> 00:13:12,929
about the GMT Seacliff as well to ask

298
00:13:17,720 --> 00:13:14,669
her what the resolution for the GMT

299
00:13:20,900 --> 00:13:17,730
would be um she gave me a couple of

300
00:13:22,340 --> 00:13:20,910
white papers but this she to take this

301
00:13:25,009 --> 00:13:22,350
they still don't have the final numbers

302
00:13:26,809 --> 00:13:25,019
on that yet but that's the case I would

303
00:13:28,809 --> 00:13:26,819
be interested in looking what what the