NASA Astrobiology Institute

Team Overview Seminars
University of Washington

1
00:00:06,590 --> 00:00:03,700
good morning or afternoon everyone

2
00:00:10,129 --> 00:00:06,600
welcome to the next in the theories of

3
00:00:12,200 --> 00:00:10,139
nai team overview seminars and this

4
00:00:14,930 --> 00:00:12,210
seminar is by a principal investigator

5
00:00:18,439 --> 00:00:14,940
who I think is well known to everybody

6
00:00:21,560 --> 00:00:18,449
Vikki Meadows who has been a p.i in the

7
00:00:24,200 --> 00:00:21,570
NAI since the second competition I think

8
00:00:27,920 --> 00:00:24,210
most people also know the general

9
00:00:29,660 --> 00:00:27,930
subject of Vickie's team as you know I

10
00:00:32,780 --> 00:00:29,670
often point out that there are some

11
00:00:35,240 --> 00:00:32,790
teams whose entire research project can

12
00:00:37,310 --> 00:00:35,250
be captured in a sentence and sometimes

13
00:00:38,119 --> 00:00:37,320

even half a sentence in the case of

14
00:00:41,000 --> 00:00:38,129
Vickie's team

15
00:00:44,840 --> 00:00:41,010
it's the audacious task of modeling and

16
00:00:47,000 --> 00:00:44,850
alien biosphere so we're going to hear

17
00:00:50,660 --> 00:00:47,010
about Vickie's progress and future plans

18
00:00:52,520 --> 00:00:50,670
on that Vicki got her bachelor's from

19
00:00:54,830 --> 00:00:52,530
the University of New South Wales which

20
00:00:58,639 --> 00:00:54,840
happens to be the home the new home of

21
00:01:01,310 --> 00:00:58,649
our Australian international partner and

22
00:01:03,049 --> 00:01:01,320
the Australian Centre for astrobiology

23
00:01:04,910 --> 00:01:03,059
led by Malcolm Walter and then she got

24
00:01:07,370 --> 00:01:04,920
her PhD in astrophysics at the

25
00:01:10,270 --> 00:01:07,380
University of Sydney in Australia she

26
00:01:13,039 --> 00:01:10,280
then moved to JPL where I believe she

27
00:01:14,660 --> 00:01:13,049
spent her entire career prior to moving

28
00:01:18,050 --> 00:01:14,670
to the University of Washington a couple

29
00:01:20,090 --> 00:01:18,060
of years ago she was an NRC postdoc a

30
00:01:22,789 --> 00:01:20,100
research scientist at the sort of

31
00:01:24,620 --> 00:01:22,799
Science Center and then of course the

32
00:01:26,780 --> 00:01:24,630
witch got converted into the Spitzer

33
00:01:30,920 --> 00:01:26,790
Science Center's so without any further

34
00:01:32,890 --> 00:01:30,930
ado Vicki I'll turn it over to you you

35
00:01:35,270 --> 00:01:32,900
very much Carl for that introduction

36
00:01:38,300 --> 00:01:35,280
okay so today I'm going to talk about

37
00:01:39,770 --> 00:01:38,310
the virtual planetary laboratory lead

38
00:01:43,999 --> 00:01:39,780

team of the NASA Astrobiology Institute

39
00:01:46,819 --> 00:01:44,009
and to inform you my fellow nei members

40
00:01:48,679 --> 00:01:46,829
about the research that we do I'll give

41
00:01:50,719 --> 00:01:48,689
you an overview of the types of areas of

42
00:01:54,710 --> 00:01:50,729
research we like to get into some of the

43
00:01:55,789 --> 00:01:54,720
major players some updates on some

44
00:01:58,100 --> 00:01:55,799
things we've done already

45
00:02:00,410 --> 00:01:58,110
as they illustrate what we're capable of

46
00:02:04,910 --> 00:02:00,420
and a discussion of our future plans as

47
00:02:07,190 --> 00:02:04,920
well so as Kyle pointed out it can be

48
00:02:09,290 --> 00:02:07,200
fairly easy to summarize what we do and

49
00:02:12,650 --> 00:02:09,300
our area of research we are firmly

50
00:02:13,559 --> 00:02:12,660
centered in exoplanet science but in

51
00:02:15,929 --> 00:02:13,569
doing that

52
00:02:18,149 --> 00:02:15,939
we also have to call upon our colleagues

53
00:02:20,429 --> 00:02:18,159
in earth observing science and also in

54
00:02:22,110 --> 00:02:20,439
the early Earth community because both

55
00:02:24,569 --> 00:02:22,120
the modern day earth and the early Earth

56
00:02:26,759 --> 00:02:24,579
are examples of habitable and inhabited

57
00:02:31,379 --> 00:02:26,769
planets so we care about those as well

58
00:02:34,140 --> 00:02:31,389
so I'm talking today but behind me there

59
00:02:37,349 --> 00:02:34,150
is a mass of people I've actually lost

60
00:02:40,979 --> 00:02:37,359
count how many we have it's something

61
00:02:43,409 --> 00:02:40,989
close to 40 but so when I show a list of

62
00:02:45,000 --> 00:02:43,419
our team here I tend to talk in

63
00:02:45,959 --> 00:02:45,010

statistics rather than individuals

64
00:02:48,209 --> 00:02:45,969
because I can't really go through

65
00:02:51,119 --> 00:02:48,219
everybody individually this is slide 1

66
00:02:52,830 --> 00:02:51,129
of 2 and so what you can see here

67
00:02:54,720 --> 00:02:52,840
statistically is that we have a very

68
00:02:57,479 --> 00:02:54,730
strong Center now at the University of

69
00:02:59,339 --> 00:02:57,489
Washington myself postdocs graduate

70
00:03:01,470 --> 00:02:59,349
students and we just recently acquired

71
00:03:03,990 --> 00:03:01,480
our colleagues from the original u-dub

72
00:03:06,420 --> 00:03:04,000
team so people like Roger Buick Peter

73
00:03:08,550 --> 00:03:06,430
Ward John Barris Jody Deming are all now

74
00:03:10,589 --> 00:03:08,560
collaborating with the BPL as well and

75
00:03:12,959 --> 00:03:10,599
I'm very very pleased to have them join

76
00:03:14,849 --> 00:03:12,969
us we have another major center of

77
00:03:17,939 --> 00:03:14,859
course at JPL and Caltech which is where

78
00:03:19,679 --> 00:03:17,949
VPL started out we have had a very very

79
00:03:21,629 --> 00:03:19,689
strong collaboration over the years with

80
00:03:23,580 --> 00:03:21,639
Penn State via Jim casting and his

81
00:03:25,920 --> 00:03:23,590
research group and that really has been

82
00:03:27,780 --> 00:03:25,930
as you will see extremely valuable in

83
00:03:31,110 --> 00:03:27,790
shaping the type of research that we do

84
00:03:33,749 --> 00:03:31,120
as well if I moved to page 2 we also

85
00:03:36,780 --> 00:03:33,759
have collaborations with NASA Ames in

86
00:03:38,369 --> 00:03:36,790
both planetary atmospheric modeling and

87
00:03:40,890 --> 00:03:38,379
chemical modeling and also in

88
00:03:43,949 --> 00:03:40,900

microbiology as well for a microbial

89
00:03:45,599 --> 00:03:43,959
mats Torrey holler Kelli Decker Dave dem

90
00:03:46,770 --> 00:03:45,609
array there we have some links with

91
00:03:48,599 --> 00:03:46,780
Goddard now through their Earth

92
00:03:50,460 --> 00:03:48,609
observing people Watson Greg Jeff

93
00:03:52,229 --> 00:03:50,470
penalty and then you can see we also

94
00:03:54,270 --> 00:03:52,239
have a list of experts distributed

95
00:03:56,280 --> 00:03:54,280
across this country and other people's

96
00:03:58,649 --> 00:03:56,290
countries who helped us out with the

97
00:04:01,740 --> 00:03:58,659
various tasks as well so we're

98
00:04:04,199 --> 00:04:01,750
distributed very highly across about 20

99
00:04:07,050 --> 00:04:04,209
institutions with about 40 people but

100
00:04:11,009 --> 00:04:07,060
centered primarily at 3 NASA centers and

101
00:04:12,659 --> 00:04:11,019
at Penn State and the you dub so that's

102
00:04:13,830 --> 00:04:12,669
our team oh and sorry just one other

103
00:04:15,390 --> 00:04:13,840
point I want to make because if you're

104
00:04:17,520 --> 00:04:15,400
looking at this right-hand column you'll

105
00:04:19,379 --> 00:04:17,530
see that we have an extreme diversity of

106
00:04:22,589 --> 00:04:19,389
disciplines in this team as well

107
00:04:25,110 --> 00:04:22,599
everything from stellar astrophysics all

108
00:04:27,330 --> 00:04:25,120
the way down to microbial

109
00:04:31,170 --> 00:04:27,340
sample horizontal gene transfer people

110
00:04:33,810 --> 00:04:31,180
who study molecular evolution alright so

111
00:04:35,100 --> 00:04:33,820
if you can say what our science was in

112
00:04:36,690 --> 00:04:35,110
VP L it is to search for habitable

113
00:04:41,060 --> 00:04:36,700

environments and life beyond the solar

114
00:04:44,040 --> 00:04:41,070
system that's where we want to work in

115
00:04:45,540 --> 00:04:44,050
current wisdom how about a planet some

116
00:04:46,590 --> 00:04:45,550
more likely to be terrestrial planets

117
00:04:48,030 --> 00:04:46,600
and they're more likely to be within

118
00:04:49,920 --> 00:04:48,040
this thing we call this circumstellar

119
00:04:52,440 --> 00:04:49,930
habitable zone so that's kind of where

120
00:04:55,290 --> 00:04:52,450
we put a lot of our research we model in

121
00:04:57,390 --> 00:04:55,300
that particular area currently as of

122
00:05:00,480 --> 00:04:57,400
this morning there are 344 extrasolar

123
00:05:02,909 --> 00:05:00,490
planets known but of those only about 10

124
00:05:04,890 --> 00:05:02,919
are less than 10 Earth masses and so

125
00:05:06,900 --> 00:05:04,900
that would be only about 10 that are

126
00:05:10,740 --> 00:05:06,910
probably terrestrial rocky type planets

127
00:05:12,629 --> 00:05:10,750
more akin to the earth than to Jupiter

128
00:05:14,879 --> 00:05:12,639
all the other tourists all the other

129
00:05:17,010 --> 00:05:14,889
extrasolar planets found so far are more

130
00:05:18,540 --> 00:05:17,020
of the Jovian type and then we can learn

131
00:05:21,600 --> 00:05:18,550
quite a bit from them especially in the

132
00:05:24,450 --> 00:05:21,610
techniques we use to study them it can

133
00:05:25,590 --> 00:05:24,460
be we think that the habit or ones are

134
00:05:26,610 --> 00:05:25,600
more likely to be the terrestrial

135
00:05:29,820 --> 00:05:26,620
planets and so that's what we

136
00:05:31,680 --> 00:05:29,830
concentrate on there so far in the ester

137
00:05:34,529 --> 00:05:31,690
solid planets sample that we have a true

138
00:05:36,450 --> 00:05:34,539

Earth analog has yet to be found but it

139
00:05:37,950 --> 00:05:36,460
won't be long I really don't think it

140
00:05:39,390 --> 00:05:37,960
will be very long at all so maybe in the

141
00:05:41,219 --> 00:05:39,400
next five years or so we'll actually

142
00:05:43,740 --> 00:05:41,229
find a true earth analog which will be

143
00:05:46,440 --> 00:05:43,750
something maybe 2 or 3 earth masses in

144
00:05:48,300 --> 00:05:46,450
the habitable zone of its parent star so

145
00:05:50,580 --> 00:05:48,310
the question we ask ourselves at VPL is

146
00:05:52,200 --> 00:05:50,590
once we find this thing how do we go

147
00:05:54,540 --> 00:05:52,210
about recognizing if an extrasolar

148
00:05:56,100 --> 00:05:54,550
terrestrial planet can or does support

149
00:05:58,260 --> 00:05:56,110
life so those are the questions of

150
00:06:01,469 --> 00:05:58,270
habitability and life the under solar

151
00:06:03,210 --> 00:06:01,479
system now in our own solar system we

152
00:06:04,379 --> 00:06:03,220
have examples of terrestrial planets so

153
00:06:05,279 --> 00:06:04,389
we might think we know what we're

154
00:06:07,529 --> 00:06:05,289
talking about when we talk about

155
00:06:09,779 --> 00:06:07,539
terrestrial planets but as our colleague

156
00:06:12,810 --> 00:06:09,789
here on the VP l2 of an effect Shaun

157
00:06:15,930 --> 00:06:12,820
Raymond and Tom Quinn working with John

158
00:06:17,760 --> 00:06:15,940
Lumine have shown is that planets and

159
00:06:20,820 --> 00:06:17,770
planetary systems can come in a very

160
00:06:22,290 --> 00:06:20,830
wide range of characteristics and what

161
00:06:23,610 --> 00:06:22,300
we're showing here in this multicolored

162
00:06:25,920 --> 00:06:23,620
plots are just a whole series of

163
00:06:27,480 --> 00:06:25,930

simulations forming planets and what we

164
00:06:28,740 --> 00:06:27,490
see is that planets can form at

165
00:06:30,840 --> 00:06:28,750
different sizes different water

166
00:06:33,000 --> 00:06:30,850
abundances different distances and so we

167
00:06:35,339 --> 00:06:33,010
expect to see that kind of diversity in

168
00:06:36,870 --> 00:06:35,349
the extrasolar planet population so we

169
00:06:38,730 --> 00:06:36,880
have to ask ourselves well how do we go

170
00:06:40,499 --> 00:06:38,740
about understand

171
00:06:42,029 --> 00:06:40,509
this potential diversity given that we

172
00:06:43,320 --> 00:06:42,039
really only have three terrestrial

173
00:06:45,360 --> 00:06:43,330
planets with atmospheres in our own

174
00:06:47,460 --> 00:06:45,370
planetary system and so the answer to

175
00:06:48,510 --> 00:06:47,470
that really is to go into the modeling

176
00:06:50,370 --> 00:06:48,520
arena

177
00:06:52,170 --> 00:06:50,380
we do take observations as well but

178
00:06:53,879 --> 00:06:52,180
again as I said we still don't have the

179
00:06:56,010 --> 00:06:53,889
sensitivity to get down to the true

180
00:07:00,210 --> 00:06:56,020
earth analogs yet even though we hope we

181
00:07:01,950 --> 00:07:00,220
will at some point so if you want to

182
00:07:03,839 --> 00:07:01,960
learn more about extrasolar planets as I

183
00:07:05,460 --> 00:07:03,849
said we we attack this by modeling but

184
00:07:07,860 --> 00:07:05,470
you can also try and go out and take

185
00:07:09,779 --> 00:07:07,870
observations and so this is where we tie

186
00:07:11,430 --> 00:07:09,789
very strongly into NASA missions and

187
00:07:12,930 --> 00:07:11,440
that is that our work will be relevant

188
00:07:14,520 --> 00:07:12,940

to both the Kepler mission and the

189
00:07:16,469 --> 00:07:14,530
terrestrial planet finder missions which

190
00:07:18,360 --> 00:07:16,479
I'll talk about in a moment so Kepler

191
00:07:20,700 --> 00:07:18,370
successfully launched last month which

192
00:07:23,790 --> 00:07:20,710
was fantastic news and it is a mission

193
00:07:25,350 --> 00:07:23,800
that will stare at the sky non-stop for

194
00:07:27,510 --> 00:07:25,360
about four years monitoring the

195
00:07:29,070 --> 00:07:27,520
brightness of stars to check for planets

196
00:07:30,749 --> 00:07:29,080
that are passing in front of their

197
00:07:31,890 --> 00:07:30,759
parent star when the planet passes in

198
00:07:34,680 --> 00:07:31,900
front of the star it causes the light

199
00:07:36,210 --> 00:07:34,690
from the planet to dim so we're able to

200
00:07:38,520 --> 00:07:36,220
pick up these planets and this

201
00:07:40,620 --> 00:07:38,530
instrument should be able to find true

202
00:07:42,420 --> 00:07:40,630
earth analogs in fact earth-mass planets

203
00:07:44,310 --> 00:07:42,430
in earth earth-like orbits around their

204
00:07:45,540 --> 00:07:44,320
parent stars so we're very much looking

205
00:07:47,700 --> 00:07:45,550
forward to the results that will come

206
00:07:50,159 --> 00:07:47,710
from that mission the other mission that

207
00:07:51,839 --> 00:07:50,169
VPL is potentially relevant to are the

208
00:07:54,570 --> 00:07:51,849
concept missions of the terrestrial

209
00:07:58,080 --> 00:07:54,580
planet finder x' they have a counterpart

210
00:08:01,020 --> 00:07:58,090
a sister mission concept in europe the

211
00:08:03,719 --> 00:08:01,030
darwin isa mission but someday we hope

212
00:08:05,999 --> 00:08:03,729
in the next 10 to 20 years to fly very

213
00:08:08,159 --> 00:08:06,009

very powerful very large telescopes that

214
00:08:10,020 --> 00:08:08,169
will be able to detect light from

215
00:08:11,999 --> 00:08:10,030
extrasolar terrestrial planets or earth

216
00:08:15,390 --> 00:08:12,009
sized things and actually take that

217
00:08:17,070 --> 00:08:15,400
light and break it into a spectrum so

218
00:08:18,959 --> 00:08:17,080
that we can look at and analyze the

219
00:08:20,969 --> 00:08:18,969
environments and to search for possible

220
00:08:24,209 --> 00:08:20,979
signs of life on extrasolar terrestrial

221
00:08:26,249 --> 00:08:24,219
planets however there's a challenge to

222
00:08:27,330 --> 00:08:26,259
understanding an extrasolar planet and

223
00:08:29,040 --> 00:08:27,340
that is because even with these

224
00:08:30,689 --> 00:08:29,050
incredibly powerful telescopes although

225
00:08:32,909 --> 00:08:30,699
it will see will be a pale blue dot

226
00:08:37,380 --> 00:08:32,919
essentially or a pale blue pixel as I've

227
00:08:39,240 --> 00:08:37,390
shown graphically here so when we try

228
00:08:41,250 --> 00:08:39,250
and learn about extrasolar terrestrial

229
00:08:43,230 --> 00:08:41,260
planets we'll come across a bunch of

230
00:08:44,639 --> 00:08:43,240
problems one is that of course our solar

231
00:08:46,019 --> 00:08:44,649
system only contains a subset of

232
00:08:47,510 --> 00:08:46,029
possible planets so we really have to

233
00:08:49,470 --> 00:08:47,520
think about other possibilities

234
00:08:51,590 --> 00:08:49,480
everything we learn about the planet

235
00:08:52,910 --> 00:08:51,600
will be from this disk average data so

236
00:08:54,170 --> 00:08:52,920
everything we want to know about its

237
00:08:55,940 --> 00:08:54,180
environment and whether or not it has

238
00:08:57,890 --> 00:08:55,950

life in it is contained in this blue

239
00:08:59,480 --> 00:08:57,900
pixel and we have to from that blue

240
00:09:01,130 --> 00:08:59,490
pixel on the spectrum that we get from

241
00:09:03,770 --> 00:09:01,140
it disentangle all the characteristics

242
00:09:05,930 --> 00:09:03,780
of a planet whether or not the planet

243
00:09:08,360 --> 00:09:05,940
has oceans continents and in fact a

244
00:09:10,790 --> 00:09:08,370
biosphere and we also have to forget

245
00:09:12,470 --> 00:09:10,800
that not to forget that clouds and dense

246
00:09:13,730 --> 00:09:12,480
atmospheres will limit our view at

247
00:09:15,560 --> 00:09:13,740
certain wavelengths so it's also

248
00:09:17,150 --> 00:09:15,570
important to try and figure out where in

249
00:09:20,840 --> 00:09:17,160
the spectrum of the planet you might be

250
00:09:23,630 --> 00:09:20,850
best able to see what's going on so in a

251
00:09:24,920 --> 00:09:23,640
nutshell what vpl does is our science is

252
00:09:26,750 --> 00:09:24,930
the search for have environments in life

253
00:09:28,280 --> 00:09:26,760
beyond the solar system our approach is

254
00:09:29,930 --> 00:09:28,290
to use self-consistent models of

255
00:09:31,910 --> 00:09:29,940
planetary environments and to generate

256
00:09:34,880 --> 00:09:31,920
spectra from those self-consistent

257
00:09:36,260 --> 00:09:34,890
environments our input to the models

258
00:09:37,940 --> 00:09:36,270
because we can't just make this map out

259
00:09:39,470 --> 00:09:37,950
of thin air even though you know

260
00:09:40,910 --> 00:09:39,480
theoreticians have a tendency to want to

261
00:09:43,160 --> 00:09:40,920
do that but we try to keep ourselves

262
00:09:45,230 --> 00:09:43,170
honest by having input from field and

263
00:09:46,790 --> 00:09:45,240

laboratory work from planetary

264
00:09:49,040 --> 00:09:46,800
observations and planets in our own

265
00:09:50,360 --> 00:09:49,050
system and extrasolar planets and also

266
00:09:52,610 --> 00:09:50,370
to gather constraints from the

267
00:09:54,050 --> 00:09:52,620
geological and biological records so in

268
00:09:55,910 --> 00:09:54,060
many ways this is where the rest of the

269
00:09:57,980 --> 00:09:55,920
NAI comes in you can help to keep us

270
00:10:00,110 --> 00:09:57,990
honest by doing the work that you would

271
00:10:01,790 --> 00:10:00,120
do but just keeping in the back of your

272
00:10:03,380 --> 00:10:01,800
mind when you discover something think

273
00:10:05,980 --> 00:10:03,390
hey I wonder if the VPL could use this

274
00:10:09,380 --> 00:10:05,990
because anything you can learn about

275
00:10:11,720 --> 00:10:09,390
microbial life metabolisms the gases

276
00:10:12,500 --> 00:10:11,730
that are given off and also constraints

277
00:10:14,720 --> 00:10:12,510
from the geological and biological

278
00:10:17,540 --> 00:10:14,730
records can in fact help us with our

279
00:10:20,210 --> 00:10:17,550
modelling effort and so our output then

280
00:10:21,920 --> 00:10:20,220
our models that allow us to provide

281
00:10:23,870 --> 00:10:21,930
improved understanding of past

282
00:10:27,980 --> 00:10:23,880
environments that cannot yet be directly

283
00:10:29,150 --> 00:10:27,990
observed so the early Earth as well as

284
00:10:31,070 --> 00:10:29,160
extrasolar terrestrial planet

285
00:10:32,990 --> 00:10:31,080
environments and from that we generate

286
00:10:34,940 --> 00:10:33,000
synthetic planetary spectra and look at

287
00:10:37,100 --> 00:10:34,950
the detectability of existing and novel

288
00:10:38,660 --> 00:10:37,110

bio signatures as an aid to these very

289
00:10:40,970 --> 00:10:38,670
large telescopes that will one day be

290
00:10:45,170 --> 00:10:40,980
designed and flown to look for these

291
00:10:46,280 --> 00:10:45,180
sorts of things so that was the BPL and

292
00:10:48,590 --> 00:10:46,290
so now I'm going to talk a little bit

293
00:10:50,180 --> 00:10:48,600
about what we mean by signs of life

294
00:10:51,860 --> 00:10:50,190
looking for them in extrasolar planets

295
00:10:53,720 --> 00:10:51,870
before I launch into or what we're

296
00:10:54,920 --> 00:10:53,730
actually doing in our individual tasks

297
00:10:55,940 --> 00:10:54,930
so this is just a little bit of

298
00:10:58,580 --> 00:10:55,950
background science to help you

299
00:11:00,080 --> 00:10:58,590
understand what comes afterwards so what

300
00:11:02,120 --> 00:11:00,090
am I talking about recognizing whether a

301
00:11:03,790 --> 00:11:02,130
dim distant pale blue dot is a habitable

302
00:11:07,060 --> 00:11:03,800
planet there's a number of things that

303
00:11:08,860 --> 00:11:07,070
can do astronomically to do that one is

304
00:11:10,630 --> 00:11:08,870
we can look at the planetary system

305
00:11:12,430 --> 00:11:10,640
environmental characteristics so what

306
00:11:15,000 --> 00:11:12,440
that means is are there other planets in

307
00:11:17,290 --> 00:11:15,010
the system can we learn something about

308
00:11:18,759 --> 00:11:17,300
the planet we're looking at its mass and

309
00:11:20,980 --> 00:11:18,769
orbital parameters and its interaction

310
00:11:22,060 --> 00:11:20,990
with the other planets in the system to

311
00:11:24,069 --> 00:11:22,070
understand whether or not it could

312
00:11:26,290 --> 00:11:24,079
potentially be habitable and so to do

313
00:11:28,180 --> 00:11:26,300

this we need what we call dynamicists

314
00:11:29,800 --> 00:11:28,190
people who actually understand the

315
00:11:30,940 --> 00:11:29,810
evolution of planetary orbits and can

316
00:11:32,050 --> 00:11:30,950
look at the interaction the

317
00:11:34,300 --> 00:11:32,060
gravitational interaction between

318
00:11:36,340 --> 00:11:34,310
planets in a particular system and so

319
00:11:38,620 --> 00:11:36,350
the VPL has dynamicists onboard as well

320
00:11:40,269 --> 00:11:38,630
to do that we can also look at the

321
00:11:42,190 --> 00:11:40,279
photometric characteristics of the

322
00:11:43,960 --> 00:11:42,200
planet and by photometry we just mean to

323
00:11:46,030 --> 00:11:43,970
measure light so we're just looking at

324
00:11:48,730 --> 00:11:46,040
the brightness of the planet in

325
00:11:50,290 --> 00:11:48,740
different colors and what I'll show

326
00:11:52,269 --> 00:11:50,300
today is what you can learn from that

327
00:11:54,519 --> 00:11:52,279
using a specific example of looking at

328
00:11:55,930 --> 00:11:54,529
the earth and but of course the most

329
00:11:57,579 --> 00:11:55,940
powerful way of determining what an

330
00:11:59,440 --> 00:11:57,589
environment is like over a great

331
00:12:01,150 --> 00:11:59,450
distance will be through a spectrum

332
00:12:03,310 --> 00:12:01,160
using spectroscopy taking a light from

333
00:12:04,930 --> 00:12:03,320
the parent object breaking evidence into

334
00:12:06,519 --> 00:12:04,940
its constituent wavelengths and looking

335
00:12:08,470 --> 00:12:06,529
for signatures from the surface and the

336
00:12:10,990 --> 00:12:08,480
atmosphere of the planet and potentially

337
00:12:12,430 --> 00:12:11,000
from its biosphere and ultimately all of

338
00:12:14,410 --> 00:12:12,440

these techniques have described our

339
00:12:15,970 --> 00:12:14,420
observational techniques but the other

340
00:12:17,620 --> 00:12:15,980
thing we're going to need to be able to

341
00:12:19,360 --> 00:12:17,630
interpret and to recognize whether or

342
00:12:21,970 --> 00:12:19,370
not our planet is habitable artifact

343
00:12:24,040 --> 00:12:21,980
models and one of the the I guess the

344
00:12:25,660 --> 00:12:24,050
starkest examples of this is the holy

345
00:12:27,190 --> 00:12:25,670
grail of habitability when we talk about

346
00:12:28,870 --> 00:12:27,200
a have real extrasolar planet

347
00:12:33,010 --> 00:12:28,880
we would like to see liquid water on the

348
00:12:34,269 --> 00:12:33,020
surface of that planet and in fact to be

349
00:12:35,889 --> 00:12:34,279
able to have liquid water you need

350
00:12:37,210 --> 00:12:35,899
certain surface conditions including a

351
00:12:39,490 --> 00:12:37,220
surface temperature above the freezing

352
00:12:41,350 --> 00:12:39,500
point of water and that may be very

353
00:12:42,910 --> 00:12:41,360
difficult to directly observe it turns

354
00:12:44,620 --> 00:12:42,920
out that being able to measure a

355
00:12:46,240 --> 00:12:44,630
temperature from the planet you don't

356
00:12:47,889 --> 00:12:46,250
necessarily get the surface temperature

357
00:12:50,079 --> 00:12:47,899
you get a temperature up somewhere in

358
00:12:51,819 --> 00:12:50,089
the atmosphere and so to be able to

359
00:12:53,319 --> 00:12:51,829
figure out the greenhouse warming that

360
00:12:54,850 --> 00:12:53,329
affects the actual surface temperature

361
00:12:57,490 --> 00:12:54,860
of the planet you will need climate

362
00:12:58,990 --> 00:12:57,500
models to be able to do that so even in

363
00:13:00,430 --> 00:12:59,000

this very basic of all measurements

364
00:13:02,199 --> 00:13:00,440
what's the surface temperature like

365
00:13:05,500 --> 00:13:02,209
could this thing be habitable we will

366
00:13:07,090 --> 00:13:05,510
need both models and observations so I'm

367
00:13:08,800 --> 00:13:07,100
just going to show you a few terrestrial

368
00:13:10,389 --> 00:13:08,810
planet spectra just very quickly just to

369
00:13:12,610 --> 00:13:10,399
give you a feel for the type of things

370
00:13:14,740 --> 00:13:12,620
that we're talking about these are model

371
00:13:16,120 --> 00:13:14,750
spectra of Venus Earth and Mars and I

372
00:13:16,530 --> 00:13:16,130
just want you to see that you know the

373
00:13:18,030 --> 00:13:16,540
Earth's

374
00:13:19,410 --> 00:13:18,040
looks quite different to the Venus and

375
00:13:21,540 --> 00:13:19,420
Mars spectrum as a lot more weirdos a

376
00:13:23,760 --> 00:13:21,550
lot more activity going on we can see a

377
00:13:25,950 --> 00:13:23,770
lot more greenhouse gases actually in

378
00:13:27,540 --> 00:13:25,960
its spectrum overall even though we can

379
00:13:30,180 --> 00:13:27,550
see that Venus and Mars are dominated by

380
00:13:31,590 --> 00:13:30,190
co2 but these are the sorts of things

381
00:13:32,910 --> 00:13:31,600
we're talking about looking for looking

382
00:13:34,710 --> 00:13:32,920
at these spectra and seeing whether we

383
00:13:36,600 --> 00:13:34,720
can cool a greenhouse gases and signs of

384
00:13:38,370 --> 00:13:36,610
life on the earth of course abundant

385
00:13:42,180 --> 00:13:38,380
oxygen is a sign of life and we see that

386
00:13:43,530 --> 00:13:42,190
at point 7 6 microns they're down in the

387
00:13:46,050 --> 00:13:43,540
and the shore would end on the earth

388
00:13:47,850 --> 00:13:46,060

spectrum you can also look in the mid

389
00:13:49,740 --> 00:13:47,860
infrared and so the celestial planet

390
00:13:52,680 --> 00:13:49,750
finder missions have been postulated to

391
00:13:54,720 --> 00:13:52,690
fly with telescopic capability in both

392
00:13:57,420 --> 00:13:54,730
the visible and the mid infrared or one

393
00:13:59,550 --> 00:13:57,430
or the other but in the mid infrared we

394
00:14:00,990 --> 00:13:59,560
start to look at very valuable things

395
00:14:03,000 --> 00:14:01,000
like carbon dioxide a very powerful

396
00:14:04,410 --> 00:14:03,010
greenhouse gas even present on the earth

397
00:14:05,340 --> 00:14:04,420
so even on a habitable planet we can

398
00:14:08,130 --> 00:14:05,350
pick that up there

399
00:14:09,750 --> 00:14:08,140
ozone again another proxies signature

400
00:14:12,030 --> 00:14:09,760
for life and also an ultraviolet shield

401
00:14:14,280 --> 00:14:12,040
on the planet and then we can also see

402
00:14:15,810 --> 00:14:14,290
the short would end of the mid-infrared

403
00:14:18,300 --> 00:14:15,820
in that blue spectrum of the earth

404
00:14:20,250 --> 00:14:18,310
things like methane and nitrous oxide so

405
00:14:22,110 --> 00:14:20,260
we start to get bio signatures from

406
00:14:23,820 --> 00:14:22,120
alternative metabolisms other than

407
00:14:27,780 --> 00:14:23,830
oxygen at photosynthesis churning up

408
00:14:29,310 --> 00:14:27,790
there so what are the global signs of

409
00:14:31,650 --> 00:14:29,320
life we talked about what we can look at

410
00:14:33,600 --> 00:14:31,660
to look for habitability you know using

411
00:14:35,670 --> 00:14:33,610
photometry we can search to see whether

412
00:14:37,500 --> 00:14:35,680
there's indications of an ocean on the

413
00:14:39,780 --> 00:14:37,510

planet is in spectrum we can look for

414
00:14:42,090 --> 00:14:39,790
greenhouse gases and trying to

415
00:14:43,290 --> 00:14:42,100
understand the surface temperature but

416
00:14:44,700 --> 00:14:43,300
through all of this we want to try and

417
00:14:46,680 --> 00:14:44,710
understand whether or not we can pick up

418
00:14:48,330 --> 00:14:46,690
signs of life so I'm going to introduce

419
00:14:49,740 --> 00:14:48,340
the concept of astronomical bio

420
00:14:51,900 --> 00:14:49,750
signatures we've had a lot of talks

421
00:14:53,460 --> 00:14:51,910
already from team members about instant

422
00:14:54,690 --> 00:14:53,470
what we call institute bio signatures

423
00:14:56,370 --> 00:14:54,700
where's where you can take a lump of

424
00:14:57,930 --> 00:14:56,380
rock and look for sterols and other

425
00:15:00,810 --> 00:14:57,940
things that may be indications of life

426
00:15:02,760 --> 00:15:00,820
in the rocket Istanbul biosignatures we

427
00:15:04,980 --> 00:15:02,770
have to try and determine if life exists

428
00:15:06,420 --> 00:15:04,990
over a distance of 10 parsecs and so

429
00:15:08,490 --> 00:15:06,430
what we're looking for a global scale

430
00:15:10,440 --> 00:15:08,500
photometric spectral or temporal

431
00:15:12,780 --> 00:15:10,450
features or time varying features that

432
00:15:14,940 --> 00:15:12,790
are indicative of life and we know from

433
00:15:16,800 --> 00:15:14,950
observing the earth that life can in

434
00:15:19,590 --> 00:15:16,810
fact provide a global scale modification

435
00:15:21,780 --> 00:15:19,600
of our atmosphere our surface and our

436
00:15:24,060 --> 00:15:21,790
appearance over time so we sort of just

437
00:15:26,700 --> 00:15:24,070
divide biocentrism these three different

438
00:15:28,230 --> 00:15:26,710

types of categories just like in Tsukuba

439
00:15:30,030 --> 00:15:28,240
ages though these astronomical

440
00:15:30,230 --> 00:15:30,040
biosignatures must always be identified

441
00:15:31,910 --> 00:15:30,240
in

442
00:15:32,780 --> 00:15:31,920
context to the planet or environment so

443
00:15:35,240 --> 00:15:32,790
we have to understand that the

444
00:15:37,850 --> 00:15:35,250
environments like to be able to figure

445
00:15:39,740 --> 00:15:37,860
out whether we have and a true

446
00:15:43,269 --> 00:15:39,750
biosignature or just some product some

447
00:15:45,320 --> 00:15:43,279
equilibrium product of a non-biological

448
00:15:46,519 --> 00:15:45,330
environment so for example the

449
00:15:48,500 --> 00:15:46,529
difference between Earth methane and

450
00:15:51,530 --> 00:15:48,510
Titan methane earth methane is seen in

451
00:15:53,630 --> 00:15:51,540
the presence of oxygen so there are

452
00:15:55,370 --> 00:15:53,640
known sinks for both of these gases on

453
00:15:57,050 --> 00:15:55,380
this planet and they have seen very

454
00:15:58,670 --> 00:15:57,060
strongly out of just out of equilibrium

455
00:16:01,190 --> 00:15:58,680
in what we call chemical disequilibrium

456
00:16:03,500 --> 00:16:01,200
that is indicative of a sign of life

457
00:16:05,810 --> 00:16:03,510
whereas I'm Titan for example the

458
00:16:08,660 --> 00:16:05,820
methane and ammonia we see there are

459
00:16:10,280 --> 00:16:08,670
really a characteristic of what the

460
00:16:12,920 --> 00:16:10,290
planet formed with and are not

461
00:16:14,420 --> 00:16:12,930
considered to be signs of life I also

462
00:16:16,040 --> 00:16:14,430
want to just introduce the concept of

463
00:16:17,540 --> 00:16:16,050

anti biosignatures which is something I

464
00:16:20,690 --> 00:16:17,550
think that they demo a first came up

465
00:16:22,460 --> 00:16:20,700
with but this idea of a free lunch the

466
00:16:23,990 --> 00:16:22,470
in fact we can also look for anti virus

467
00:16:25,519 --> 00:16:24,000
signatures signs on a planet that there

468
00:16:26,960 --> 00:16:25,529
are abundant gases around that really

469
00:16:28,910 --> 00:16:26,970
life would have jumped on immediately if

470
00:16:30,350 --> 00:16:28,920
it possibly could and I know yuk Yuen

471
00:16:32,570 --> 00:16:30,360
often talks about this as the floating

472
00:16:33,920 --> 00:16:32,580
$20 bills so where we can also

473
00:16:35,269 --> 00:16:33,930
potentially look for things that have

474
00:16:37,699 --> 00:16:35,279
build up in an atmosphere that would

475
00:16:40,060 --> 00:16:37,709
normally be consumed by life to let us

476
00:16:43,400 --> 00:16:40,070
know that potentially life is not there

477
00:16:44,750 --> 00:16:43,410
so looking again spectroscopically if

478
00:16:46,130 --> 00:16:44,760
these things the signs of life in an

479
00:16:48,740 --> 00:16:46,140
atmosphere would be things like the

480
00:16:50,810 --> 00:16:48,750
simultaneous present presence of oxygen

481
00:16:53,150 --> 00:16:50,820
or ozone its proxy and methane and

482
00:16:56,199 --> 00:16:53,160
nitrous oxide I'm also showing just some

483
00:16:58,250 --> 00:16:56,209
habitability markers here co2 and water

484
00:17:00,519 --> 00:16:58,260
when you're talking about atmospheric

485
00:17:02,780 --> 00:17:00,529
biasing shows you really are looking at

486
00:17:04,130 --> 00:17:02,790
three different processes and this is

487
00:17:06,679 --> 00:17:04,140
something we have to worry about it and

488
00:17:08,510 --> 00:17:06,689

vpl to have a good atmosphere biasing

489
00:17:09,770 --> 00:17:08,520
turreted to find one or recognize one

490
00:17:11,419 --> 00:17:09,780
you need to know that there's a

491
00:17:12,919 --> 00:17:11,429
biological source for it so we care

492
00:17:14,870 --> 00:17:12,929
about what metabolisms are putting out

493
00:17:17,120 --> 00:17:14,880
you need to understand it's atmospheric

494
00:17:18,319 --> 00:17:17,130
lifetime on the planet to how long it

495
00:17:19,579 --> 00:17:18,329
hangs around in the atmosphere the

496
00:17:20,900 --> 00:17:19,589
longer it hangs around the more of it

497
00:17:23,569 --> 00:17:20,910
builds up the more likely we are to see

498
00:17:25,130 --> 00:17:23,579
it that Amstrad lifetime is a function

499
00:17:27,410 --> 00:17:25,140
of the interaction of the planet with

500
00:17:29,030 --> 00:17:27,420
its parent star as well as the planetary

501
00:17:30,890 --> 00:17:29,040
processes themselves a lot of

502
00:17:32,120 --> 00:17:30,900
photochemistry are still and driven so

503
00:17:34,160 --> 00:17:32,130
we do also have to understand a lot

504
00:17:35,720 --> 00:17:34,170
about what the stars are like I'm sorry

505
00:17:37,130 --> 00:17:35,730
and I'll just get back the other thing

506
00:17:40,280 --> 00:17:37,140
is that the BIOS signature should

507
00:17:42,440 --> 00:17:40,290
produce a spectral feature and that

508
00:17:43,790 --> 00:17:42,450
isn't always a given and when we fly

509
00:17:45,380 --> 00:17:43,800
these telescopes we may have

510
00:17:47,060 --> 00:17:45,390
fairly limited wavelength ranges in

511
00:17:48,950 --> 00:17:47,070
which to work in so we always have to

512
00:17:50,660 --> 00:17:48,960
care too about what the impact of this

513
00:17:51,770 --> 00:17:50,670

gas is on the spectrum of the planet and

514
00:17:55,760 --> 00:17:51,780
whether or not we would have to take

515
00:17:56,410 --> 00:17:55,770
ability to see it so we talked about

516
00:17:58,310 --> 00:17:56,420
oxygen

517
00:18:01,580 --> 00:17:58,320
photosynthesis that is sort of the

518
00:18:03,320 --> 00:18:01,590
classic metabolism that is considered to

519
00:18:06,290 --> 00:18:03,330
have biosensors that we can look for

520
00:18:07,520 --> 00:18:06,300
things like oxygen and ozone but a vpl

521
00:18:09,200 --> 00:18:07,530
we are also concerned about other

522
00:18:11,390 --> 00:18:09,210
potential biosignatures things like

523
00:18:13,400 --> 00:18:11,400
methane things like methyl chloride

524
00:18:15,620 --> 00:18:13,410
nitrous oxide which we can get from

525
00:18:17,750 --> 00:18:15,630
various sources even ammonia and certain

526
00:18:19,610 --> 00:18:17,760
instances can be a Meyer signature we

527
00:18:22,520 --> 00:18:19,620
care about other methylated compounds

528
00:18:24,350 --> 00:18:22,530
and ultimately again here's where we

529
00:18:25,700 --> 00:18:24,360
turn to you and say hey please advise us

530
00:18:29,270 --> 00:18:25,710
if you have you know an interesting

531
00:18:31,760 --> 00:18:29,280
metabolism that you think might alter

532
00:18:33,230 --> 00:18:31,770
the atmosphere in particular that's

533
00:18:35,890 --> 00:18:33,240
that's something we would really like to

534
00:18:38,330 --> 00:18:35,900
know about from our fellow team members

535
00:18:39,680 --> 00:18:38,340
so that was a destroyed by stinkers the

536
00:18:41,270 --> 00:18:39,690
other biosignatures we can think over

537
00:18:42,500 --> 00:18:41,280
the surface biosignatures the most

538
00:18:44,810 --> 00:18:42,510

characteristic one is something called

539
00:18:47,090 --> 00:18:44,820
red edge and this is a rise in

540
00:18:49,700 --> 00:18:47,100
reflectivity longwood of about 0.7

541
00:18:51,320 --> 00:18:49,710
microns in vegetation which is due to a

542
00:18:52,760 --> 00:18:51,330
combination of chlorophyll absorption

543
00:18:55,490 --> 00:18:52,770
and a change in the scattering

544
00:18:57,770 --> 00:18:55,500
properties of the leaf structure and

545
00:19:00,440 --> 00:18:57,780
that is what Landsat uses for example

546
00:19:02,150 --> 00:19:00,450
from from orbit to determine that the

547
00:19:04,280 --> 00:19:02,160
Brazilian rainforest is disappearing it

548
00:19:05,810 --> 00:19:04,290
uses a ratio between that rise and the

549
00:19:08,300 --> 00:19:05,820
chlorophyll absorption to tell where

550
00:19:10,520 --> 00:19:08,310
vegetation is underneath it turns out we

551
00:19:13,640 --> 00:19:10,530
could potentially use that on an

552
00:19:15,710 --> 00:19:13,650
extrasolar planet to look for vegetation

553
00:19:17,210 --> 00:19:15,720
signatures the only problem with looking

554
00:19:19,430 --> 00:19:17,220
for a vegetation signature in the disk

555
00:19:20,930 --> 00:19:19,440
average of a planet is that the

556
00:19:22,430 --> 00:19:20,940
vegetation itself may take up a very

557
00:19:24,200 --> 00:19:22,440
small fraction of the surface of the

558
00:19:26,720 --> 00:19:24,210
planet and so that signature may be

559
00:19:28,460 --> 00:19:26,730
swamped by other characteristics of the

560
00:19:30,980 --> 00:19:28,470
planet including clouds in particular

561
00:19:33,050 --> 00:19:30,990
which both reflect a lot of visible

562
00:19:34,610 --> 00:19:33,060
radiation providing making it much more

563
00:19:35,870 --> 00:19:34,620

difficult to see the vegetation and of

564
00:19:38,270 --> 00:19:35,880
course also physically cover the

565
00:19:40,130 --> 00:19:38,280
vegetation up so what we have here is a

566
00:19:42,200 --> 00:19:40,140
simulation from the VPL that we've done

567
00:19:43,640 --> 00:19:42,210
in the past just looking at the disk

568
00:19:45,470 --> 00:19:43,650
average spectrum of the earth when you

569
00:19:46,900 --> 00:19:45,480
see different views on the earth and I'm

570
00:19:51,110 --> 00:19:46,910
going to attempt to use the cursor here

571
00:19:54,530 --> 00:19:51,120
but oops blush okay I'm trying to center

572
00:19:56,030 --> 00:19:54,540
over the Pacific here close enough so

573
00:19:56,340 --> 00:19:56,040
what we're looking at here is if you

574
00:19:58,080 --> 00:19:56,350
look at

575
00:20:00,120 --> 00:19:58,090
spectrum on this plot this is actually a

576
00:20:02,190 --> 00:20:00,130
spectrum of the disc averaged Pacific

577
00:20:05,100 --> 00:20:02,200
earth and you can see that there's very

578
00:20:08,640 --> 00:20:05,110
little rise in radiation between that

579
00:20:11,039 --> 00:20:08,650
blue area and the pink area whereas if

580
00:20:13,680 --> 00:20:11,049
you look at the Green Line for example

581
00:20:15,930 --> 00:20:13,690
which is showing you the area of the

582
00:20:18,659 --> 00:20:15,940
Americas and over Brazil you can see a

583
00:20:24,000 --> 00:20:18,669
very sharp rise a very sharp difference

584
00:20:27,120 --> 00:20:24,010
between the radiations seen here for the

585
00:20:29,220 --> 00:20:27,130
for the for the Pacific and here when we

586
00:20:30,210 --> 00:20:29,230
go over Brazil now we were cheating here

587
00:20:32,310 --> 00:20:30,220
this is one of our three-dimensional

588
00:20:35,010 --> 00:20:32,320

models we took all the clouds away so we

589
00:20:37,110 --> 00:20:35,020
showed you the maximum effect of the red

590
00:20:38,940 --> 00:20:37,120
edge even in the disk average if we add

591
00:20:41,430 --> 00:20:38,950
the clouds back in that effect drops to

592
00:20:43,590 --> 00:20:41,440
about a 1 or 2% effect making it quite

593
00:20:44,399 --> 00:20:43,600
difficult to observe not impossible but

594
00:20:46,789 --> 00:20:44,409
certainly one of the more challenging

595
00:20:48,960 --> 00:20:46,799
bio signatures for an extrasolar planet

596
00:20:50,840 --> 00:20:48,970
the other type of biosignature we're

597
00:20:54,000 --> 00:20:50,850
concerned with is temporal variability

598
00:20:55,440 --> 00:20:54,010
so how things change on a planet as a

599
00:20:57,390 --> 00:20:55,450
function of seasons and whether or not

600
00:20:59,460 --> 00:20:57,400
that is indicative of life processes and

601
00:21:01,320 --> 00:20:59,470
here is an example we actually showed

602
00:21:04,440 --> 00:21:01,330
the annual variation in carbon dioxide

603
00:21:07,230 --> 00:21:04,450
and the ominous staccato rise in carbon

604
00:21:08,520 --> 00:21:07,240
dioxide over time so these these bumps

605
00:21:11,190 --> 00:21:08,530
and Wiggles you're seeing are in fact

606
00:21:12,630 --> 00:21:11,200
the changes in co2 now co2 can be

607
00:21:14,070 --> 00:21:12,640
produced by volcanoes which is an

608
00:21:17,310 --> 00:21:14,080
abiotic process but you don't normally

609
00:21:19,560 --> 00:21:17,320
expect volcanoes to be seasonal so we

610
00:21:21,330 --> 00:21:19,570
could monitor a planet over time to try

611
00:21:22,380 --> 00:21:21,340
and see if any of these particular gases

612
00:21:26,580 --> 00:21:22,390
that are potentially produced by

613
00:21:27,659 --> 00:21:26,590

metabolism modified with seasons so I'm

614
00:21:30,390 --> 00:21:27,669
now going to start talking about what

615
00:21:32,970 --> 00:21:30,400
the VPO does that was an overview of

616
00:21:35,090 --> 00:21:32,980
biosignatures but essentially at the

617
00:21:37,590 --> 00:21:35,100
heart of what we do is we take models

618
00:21:39,480 --> 00:21:37,600
that can be used to describe planetary

619
00:21:41,190 --> 00:21:39,490
environments and also we use models that

620
00:21:42,720 --> 00:21:41,200
are used for planet formation or to

621
00:21:44,399 --> 00:21:42,730
describe the evolution of chemistry in a

622
00:21:47,340 --> 00:21:44,409
protoplanetary disk so we go back that

623
00:21:50,669 --> 00:21:47,350
far but but principally what we use our

624
00:21:52,710 --> 00:21:50,679
models of extrasolar planet environments

625
00:21:55,980 --> 00:21:52,720
that take into account photo chemistry

626
00:21:57,539 --> 00:21:55,990
and climate on that particular planet so

627
00:21:59,669 --> 00:21:57,549
climate tells us about the temperature

628
00:22:01,620 --> 00:21:59,679
and pressure distribution within the

629
00:22:02,880 --> 00:22:01,630
atmosphere and the photochemical models

630
00:22:05,490 --> 00:22:02,890
tell us about the vertical distribution

631
00:22:07,169 --> 00:22:05,500
of gases in the atmosphere and we can

632
00:22:09,060 --> 00:22:07,179
couple these two models together so they

633
00:22:10,050 --> 00:22:09,070
can talk to each other and come to a

634
00:22:11,760 --> 00:22:10,060
self-consistent

635
00:22:13,110 --> 00:22:11,770
Librium so that the gases in the

636
00:22:15,600 --> 00:22:13,120
atmosphere and the temperature and

637
00:22:17,370 --> 00:22:15,610
pressure are all consistent with each

638
00:22:19,500 --> 00:22:17,380

other and we're not creating you know

639
00:22:21,150 --> 00:22:19,510
what I call Frankenstein planets where

640
00:22:22,230 --> 00:22:21,160
you just pop things together and hope

641
00:22:24,480 --> 00:22:22,240
that all the bits and pieces will

642
00:22:26,310 --> 00:22:24,490
actually stick and hold in this case we

643
00:22:27,900 --> 00:22:26,320
really do allow these things to interact

644
00:22:29,310 --> 00:22:27,910
with each other come to equilibrium and

645
00:22:31,230 --> 00:22:29,320
give us something where for example

646
00:22:33,270 --> 00:22:31,240
warming in the stratosphere is governed

647
00:22:35,520 --> 00:22:33,280
by how much ozone is actually there for

648
00:22:37,470 --> 00:22:35,530
example so we used a couple climate

649
00:22:40,260 --> 00:22:37,480
chemical models and then once we have

650
00:22:42,720 --> 00:22:40,270
our our atmosphere and by the way we can

651
00:22:45,510 --> 00:22:42,730
also lose gases out of the top and we

652
00:22:47,310 --> 00:22:45,520
can feed fluxes of gases into the bottom

653
00:22:49,080 --> 00:22:47,320
of the atmosphere via the surface from

654
00:22:51,750 --> 00:22:49,090
either volcanic or biological processes

655
00:22:53,670 --> 00:22:51,760
once we have these models are in

656
00:22:55,170 --> 00:22:53,680
equilibrium and we have or close as

657
00:22:57,240 --> 00:22:55,180
close to equilibriums one can get in

658
00:22:59,940 --> 00:22:57,250
this kind of situation we can then

659
00:23:02,340 --> 00:22:59,950
produce spectra of them and have a look

660
00:23:04,860 --> 00:23:02,350
at what they look like also around stars

661
00:23:07,050 --> 00:23:04,870
of different spectral type so we can

662
00:23:09,720 --> 00:23:07,060
take our our planet in this case we

663
00:23:11,910 --> 00:23:09,730

often take the earth we take out our G

664
00:23:14,070 --> 00:23:11,920
star throw that away replace it with an

665
00:23:16,380 --> 00:23:14,080
F star hütter star than the earth or an

666
00:23:18,180 --> 00:23:16,390
M star much cooler star and look at how

667
00:23:19,740 --> 00:23:18,190
the radiation coming from the star

668
00:23:22,050 --> 00:23:19,750
interacts with the photochemistry and

669
00:23:24,660 --> 00:23:22,060
the climate of that planet to tell us

670
00:23:26,910 --> 00:23:24,670
what kind of an end result of atmosphere

671
00:23:28,650 --> 00:23:26,920
we would have and ultimately how does

672
00:23:29,760 --> 00:23:28,660
that change the detectability of certain

673
00:23:33,150 --> 00:23:29,770
things we would normally take for

674
00:23:34,590 --> 00:23:33,160
granted like ozone for example and I

675
00:23:36,570 --> 00:23:34,600
guess what we're showing down in this

676
00:23:39,450 --> 00:23:36,580
plot here if I can move my cursor

677
00:23:41,970 --> 00:23:39,460
without the whiplash we go down in this

678
00:23:43,770 --> 00:23:41,980
plot here the spectra this was one case

679
00:23:45,690 --> 00:23:43,780
where we actually took an earth-like

680
00:23:47,580 --> 00:23:45,700
planet put it around an F star and

681
00:23:49,170 --> 00:23:47,590
discovered that in fact ozone was less

682
00:23:50,880 --> 00:23:49,180
detectable even though we had produced

683
00:23:52,020 --> 00:23:50,890
more of it and that was due to an

684
00:23:53,640 --> 00:23:52,030
interaction between the actual

685
00:23:55,380 --> 00:23:53,650
temperature structure in the atmosphere

686
00:23:57,450 --> 00:23:55,390
and the amount of ozone available and

687
00:23:58,890 --> 00:23:57,460
that was not an intuitive results but

688
00:24:00,630 --> 00:23:58,900

only through the modeling we discovered

689
00:24:04,130 --> 00:24:00,640
that oh yes with more ozone it's

690
00:24:10,740 --> 00:24:07,740
so the VPL for D which is our second

691
00:24:12,480 --> 00:24:10,750
incarnation really is built around a

692
00:24:14,850 --> 00:24:12,490
series of nested models these couple of

693
00:24:16,860 --> 00:24:14,860
climate chemical models the fluxes that

694
00:24:19,080 --> 00:24:16,870
feed into them from the bottom of the

695
00:24:21,000 --> 00:24:19,090
atmosphere and the loss from the top of

696
00:24:22,830 --> 00:24:21,010
the atmosphere we have what we call an

697
00:24:23,280 --> 00:24:22,840
abiotic planet model which doesn't have

698
00:24:24,390 --> 00:24:23,290
a bias

699
00:24:25,800 --> 00:24:24,400
very net where we really concern

700
00:24:28,440 --> 00:24:25,810
ourselves more with the habitability of

701
00:24:30,480 --> 00:24:28,450
the planet without life on it and then

702
00:24:32,430 --> 00:24:30,490
we have a suite of models which fall

703
00:24:34,170 --> 00:24:32,440
under the living planet model where we

704
00:24:37,080 --> 00:24:34,180
actually have a biosphere interacting

705
00:24:39,090 --> 00:24:37,090
with the environment and in all of these

706
00:24:42,440 --> 00:24:39,100
we also need stellar spectra as input

707
00:24:45,270 --> 00:24:42,450
and also information on molecular

708
00:24:47,310 --> 00:24:45,280
characteristics so absorption

709
00:24:49,080 --> 00:24:47,320
coefficients where something absorbs how

710
00:24:51,990 --> 00:24:49,090
strongly it absorbs in the atmosphere

711
00:24:53,970 --> 00:24:52,000
and just in the lab so our research

712
00:24:55,380 --> 00:24:53,980
objectives are to characterize

713
00:24:57,180 --> 00:24:55,390

habitability and biosignatures for an

714
00:24:58,590 --> 00:24:57,190
earth-like planet to understand the

715
00:24:59,880 --> 00:24:58,600
climate and biosignatures of the earth

716
00:25:01,620 --> 00:24:59,890
through time because again that's an

717
00:25:04,350 --> 00:25:01,630
example of a habitable planet that's

718
00:25:06,270 --> 00:25:04,360
actually inhabited to look at extrasolar

719
00:25:08,160 --> 00:25:06,280
terrestrial planet environments with the

720
00:25:09,870 --> 00:25:08,170
the key to looking at the limits of

721
00:25:11,550 --> 00:25:09,880
habitability and also to concern

722
00:25:13,590 --> 00:25:11,560
ourselves with the generation of false

723
00:25:15,660 --> 00:25:13,600
positives signatures that come from an

724
00:25:16,800 --> 00:25:15,670
abiotic planet that might mimic the

725
00:25:19,020 --> 00:25:16,810
signs of life that we think we

726
00:25:20,730 --> 00:25:19,030
understand we look at the impact of life

727
00:25:22,410 --> 00:25:20,740
on terrestrial planet environments and

728
00:25:24,570 --> 00:25:22,420
the detectability of bio signatures and

729
00:25:26,460 --> 00:25:24,580
ultimately at the end of it because we

730
00:25:27,780 --> 00:25:26,470
want this work to be relevant to TPF and

731
00:25:29,970 --> 00:25:27,790
other planet detection and

732
00:25:31,290 --> 00:25:29,980
characterization missions we look at

733
00:25:33,330 --> 00:25:31,300
what we need to actually characterize

734
00:25:34,710 --> 00:25:33,340
extrasolar terrestrial planets the

735
00:25:36,420 --> 00:25:34,720
required measurements we might have to

736
00:25:39,960 --> 00:25:36,430
make and the data analysis that we would

737
00:25:42,600 --> 00:25:39,970
have to do so those objectives map on to

738
00:25:44,250 --> 00:25:42,610

five basic tasks the earth through a

739
00:25:47,460 --> 00:25:44,260
year the earth through time the abiotic

740
00:25:48,780 --> 00:25:47,470
planet and the living planet and they

741
00:25:51,030 --> 00:25:48,790
all feed through this thing called the

742
00:25:53,130 --> 00:25:51,040
observer which is our modeling system

743
00:25:54,780 --> 00:25:53,140
that allows us to transform our

744
00:25:58,260 --> 00:25:54,790
scientific results into something that

745
00:25:59,640 --> 00:25:58,270
might be useful to telescope planners so

746
00:26:02,280 --> 00:25:59,650
I'm going to go through the tasks now in

747
00:26:04,800 --> 00:26:02,290
the second half of this talk our first

748
00:26:06,420 --> 00:26:04,810
task is the earth through a year so

749
00:26:08,130 --> 00:26:06,430
again we want to understand bias

750
00:26:10,560 --> 00:26:08,140
nature's best place to go really is the

751
00:26:12,270 --> 00:26:10,570
planet that has them and so when we

752
00:26:14,940 --> 00:26:12,280
initially envisage this task it was just

753
00:26:17,490 --> 00:26:14,950
vpl alone but since we've been funded

754
00:26:19,980 --> 00:26:17,500
another mission was under the matter's

755
00:26:21,660 --> 00:26:19,990
epic reuse of the Deep Impact spacecraft

756
00:26:23,610 --> 00:26:21,670
which is actually observing the Earth

757
00:26:25,830 --> 00:26:23,620
from space so we now have a very strong

758
00:26:29,460 --> 00:26:25,840
collaboration between VPL and the air

759
00:26:31,830 --> 00:26:29,470
park which is now epoxy science team to

760
00:26:33,750 --> 00:26:31,840
use the VPL models to analyze the data

761
00:26:37,180 --> 00:26:33,760
that's coming from this spacecraft

762
00:26:38,770 --> 00:26:37,190
observing the earth so in this task

763
00:26:40,270 --> 00:26:38,780

we use 3-dimensional especially

764
00:26:42,610 --> 00:26:40,280
especially resolved models of the earth

765
00:26:43,690 --> 00:26:42,620
so we can take the earth and in fact

766
00:26:46,720 --> 00:26:43,700
simulate what it would look like

767
00:26:49,390 --> 00:26:46,730
spectroscopically by feeding in actual

768
00:26:51,010 --> 00:26:49,400
earth observations on a given day and

769
00:26:53,190 --> 00:26:51,020
using a radiative transfer model to

770
00:26:55,780 --> 00:26:53,200
generate spectra of the of the planet

771
00:26:57,700 --> 00:26:55,790
we've been doing upgrades on that

772
00:27:01,300 --> 00:26:57,710
particular model which we brought over

773
00:27:04,600 --> 00:27:01,310
from our first round is the VP L so we

774
00:27:06,670 --> 00:27:04,610
are I've upgraded it to use an ocean

775
00:27:08,890 --> 00:27:06,680
reflectance model cuts month model to

776
00:27:11,440 --> 00:27:08,900
simulate Sun glint on the on the earth

777
00:27:13,360 --> 00:27:11,450
we're in the process of putting in

778
00:27:14,200 --> 00:27:13,370
polarization capability as well those

779
00:27:17,200 --> 00:27:14,210
people are now thinking about

780
00:27:20,350 --> 00:27:17,210
polarization biosignatures for

781
00:27:22,120 --> 00:27:20,360
extrasolar planets our grad student here

782
00:27:23,560 --> 00:27:22,130
ty robinson has expanded the surface

783
00:27:25,090 --> 00:27:23,570
spatial resolution providing us with

784
00:27:26,890 --> 00:27:25,100
more land surfaces so this is a better

785
00:27:29,230 --> 00:27:26,900
model and all of this really is driven

786
00:27:31,540 --> 00:27:29,240
by trying to validate the model against

787
00:27:33,190 --> 00:27:31,550
the EPOXI data we've been improving

788
00:27:36,100 --> 00:27:33,200

optical properties for carbon dioxide

789
00:27:37,930 --> 00:27:36,110
methane and oxygen because we need those

790
00:27:39,130 --> 00:27:37,940
to simulate what we see from the earth

791
00:27:40,870 --> 00:27:39,140
but they're also important for our

792
00:27:44,230 --> 00:27:40,880
modeling overall for terrestrial planets

793
00:27:46,330 --> 00:27:44,240
and Javier at JPL has been working on

794
00:27:48,070 --> 00:27:46,340
adding non LTE to already a to transform

795
00:27:50,680 --> 00:27:48,080
a model as well so we can actually do a

796
00:27:52,120 --> 00:27:50,690
raw ray and other processes and better

797
00:27:54,190 --> 00:27:52,130
understand some of the things that drive

798
00:27:56,410 --> 00:27:54,200
atmospheric escape so all of these

799
00:27:57,850 --> 00:27:56,420
additions to the model on effect impact

800
00:28:00,610 --> 00:27:57,860
other tasks that we're working on as

801
00:28:02,440 --> 00:28:00,620
well so in the earth through a year the

802
00:28:05,080 --> 00:28:02,450
current components are involved this

803
00:28:07,420 --> 00:28:05,090
model validation of the EPOXI data I

804
00:28:08,950 --> 00:28:07,430
want to say that the EPOXI data set is

805
00:28:10,780 --> 00:28:08,960
very nice we've used the EPOXI

806
00:28:13,660 --> 00:28:10,790
spacecraft from a distance of about 0.3

807
00:28:15,400 --> 00:28:13,670
au and closer to look at the earth and

808
00:28:18,670 --> 00:28:15,410
get time-resolved multiwave and

809
00:28:20,290 --> 00:28:18,680
photometry to get this hemispherical e

810
00:28:22,620 --> 00:28:20,300
average near infrared spectroscopy so I

811
00:28:25,300 --> 00:28:22,630
can search for those time-dependent

812
00:28:27,760 --> 00:28:25,310
signatures of variability and methane

813
00:28:29,230 --> 00:28:27,770

and n co2 over seasons we have seasonal

814
00:28:31,000 --> 00:28:29,240
observations we have the earth observed

815
00:28:33,100 --> 00:28:31,010
in several seasons we have both

816
00:28:35,170 --> 00:28:33,110
equatorial and polar views now of the

817
00:28:36,810 --> 00:28:35,180
planet and we were able to as you can

818
00:28:38,650 --> 00:28:36,820
see in this graphic luckily

819
00:28:41,170 --> 00:28:38,660
serendipitously picked up a lunar

820
00:28:43,000 --> 00:28:41,180
transit of the moon across the earth so

821
00:28:46,510 --> 00:28:43,010
we can also study a terrestrial planet

822
00:28:48,310 --> 00:28:46,520
undergoing its own transit so at the

823
00:28:49,470 --> 00:28:48,320
moment we are using these datasets to

824
00:28:51,539 --> 00:28:49,480
model and understand

825
00:28:52,859 --> 00:28:51,549
the detectability of things like ocean

826
00:28:54,330 --> 00:28:52,869
glints that would be a direct way of

827
00:28:56,220 --> 00:28:54,340
detecting whether or not a planet has

828
00:28:58,590 --> 00:28:56,230
liquid water on its surface to look at

829
00:29:00,570 --> 00:28:58,600
surface types and just look at the

830
00:29:02,129 --> 00:29:00,580
seasonal gas variations how well we can

831
00:29:04,649 --> 00:29:02,139
pick these different characteristics out

832
00:29:06,810 --> 00:29:04,659
of the planet so here's just to give you

833
00:29:08,519 --> 00:29:06,820
an example of some of the datasets we

834
00:29:11,009 --> 00:29:08,529
have so these are observations taken by

835
00:29:15,629 --> 00:29:11,019
epoxy and this mission by the way is PID

836
00:29:17,909 --> 00:29:15,639
by Drake Demi out of Goddard and so what

837
00:29:19,409 --> 00:29:17,919
we have here are light curves actually

838
00:29:21,090 --> 00:29:19,419

so this is the brightness of the planet

839
00:29:25,220 --> 00:29:21,100
over time and a bunch of different

840
00:29:27,840 --> 00:29:25,230
wavelengths team members working here at

841
00:29:29,879 --> 00:29:27,850
the U dub of actually taken those light

842
00:29:31,799 --> 00:29:29,889
curves and used a principle component

843
00:29:34,680 --> 00:29:31,809
analysis to pull out to what we call

844
00:29:36,869 --> 00:29:34,690
eigenvectors to characteristic spectra

845
00:29:38,399 --> 00:29:36,879
that if we take these two spectra and

846
00:29:41,070 --> 00:29:38,409
just add them together in components

847
00:29:42,330 --> 00:29:41,080
seem to explain a lot of the behavior we

848
00:29:44,759 --> 00:29:42,340
see in the light curves at different

849
00:29:46,320 --> 00:29:44,769
wavelengths and the two eigen spectra

850
00:29:49,529 --> 00:29:46,330
that we pulled out with no a priori

851
00:29:50,580 --> 00:29:49,539
knowledge of what we were looking at we

852
00:29:53,279 --> 00:29:50,590
have to keep forgetting we're looking at

853
00:29:55,109 --> 00:29:53,289
the earth actually produced spectra that

854
00:29:57,239 --> 00:29:55,119
look very characteristic of an ocean and

855
00:29:59,129 --> 00:29:57,249
of land surfaces so you can see in the

856
00:30:01,289 --> 00:29:59,139
top plot there the blue curve is an

857
00:30:03,960 --> 00:30:01,299
ocean curve the red one as land surfaces

858
00:30:05,849 --> 00:30:03,970
and below it our actual spectra of

859
00:30:07,499 --> 00:30:05,859
oceans and land surfaces in red and blue

860
00:30:09,239 --> 00:30:07,509
so you can see that the eigen spectra we

861
00:30:11,639 --> 00:30:09,249
picked out were pretty characteristic

862
00:30:13,470 --> 00:30:11,649
and so what we're able to do is having

863
00:30:15,749 --> 00:30:13,480

picked those out we can then do this map

864
00:30:19,080 --> 00:30:15,759
that you see down below the actual earth

865
00:30:21,749 --> 00:30:19,090
projection here this map which actually

866
00:30:24,840 --> 00:30:21,759
tells us when we see more ocean and more

867
00:30:26,549 --> 00:30:24,850
land on this planet and what we can

868
00:30:29,609 --> 00:30:26,559
point out here which I think was very

869
00:30:31,499 --> 00:30:29,619
exciting is that we actually do we are

870
00:30:33,720 --> 00:30:31,509
able to map the position of the Atlantic

871
00:30:35,879 --> 00:30:33,730
and the Pacific just using time-resolved

872
00:30:37,680 --> 00:30:35,889
photometry so this is an example of the

873
00:30:39,509 --> 00:30:37,690
sort of capability when we have either

874
00:30:41,190 --> 00:30:39,519
data or models looking at the

875
00:30:43,019 --> 00:30:41,200
detectability of these things even if

876
00:30:44,669 --> 00:30:43,029
they all we have is this disc average

877
00:30:49,499 --> 00:30:44,679
light curve of the planet the disc

878
00:30:51,779 --> 00:30:49,509
average photometry okay so our future

879
00:30:54,720 --> 00:30:51,789
work is looking at the earth through a

880
00:30:56,909 --> 00:30:54,730
year this graphic down here just shows

881
00:30:59,369 --> 00:30:56,919
an example of the the actual vpl earth

882
00:31:01,080 --> 00:30:59,379
model output for 450 nanometers so we

883
00:31:01,570 --> 00:31:01,090
can create artificial views of the earth

884
00:31:03,940 --> 00:31:01,580
on

885
00:31:07,330 --> 00:31:03,950
and day we actually fed into this earth

886
00:31:10,090 --> 00:31:07,340
model data equals modus and airs cloud

887
00:31:11,950 --> 00:31:10,100
information and for comparison you can

888
00:31:13,990 --> 00:31:11,960

see the EPOXI observation taken on the

889
00:31:15,490 --> 00:31:14,000
same day at the same wavelength we're

890
00:31:17,350 --> 00:31:15,500
not quite getting the clouds right at

891
00:31:18,970 --> 00:31:17,360
the moment and we're working on better

892
00:31:22,360 --> 00:31:18,980
understanding how we're using our input

893
00:31:24,490 --> 00:31:22,370
data and just improving our model

894
00:31:25,840 --> 00:31:24,500
overall with its sensitivity so this is

895
00:31:27,910 --> 00:31:25,850
what we're planning to do in the future

896
00:31:29,710 --> 00:31:27,920
with this we would like to actually

897
00:31:31,450 --> 00:31:29,720
model the earth through an entire years

898
00:31:34,270 --> 00:31:31,460
orbit and use that essentially as a

899
00:31:36,100 --> 00:31:34,280
laboratory a set of data sets to help

900
00:31:37,690 --> 00:31:36,110
understand how detectable some of these

901
00:31:39,760 --> 00:31:37,700
characteristics are in the presence of

902
00:31:41,740 --> 00:31:39,770
realistic clouds so looking at

903
00:31:43,270 --> 00:31:41,750
atmospheric virus signatures or red edge

904
00:31:45,580 --> 00:31:43,280
biosignatures are in that particular

905
00:31:47,170 --> 00:31:45,590
case and also looking at how effective

906
00:31:49,570 --> 00:31:47,180
we are with different types of temporal

907
00:31:51,250 --> 00:31:49,580
sampling from the telescope at being

908
00:31:53,470 --> 00:31:51,260
able to pull out some of these fire

909
00:31:54,640 --> 00:31:53,480
signatures on the earth and we've also

910
00:31:56,440 --> 00:31:54,650
been talking with the Venus Express

911
00:31:57,940 --> 00:31:56,450
folks who also have observations of the

912
00:32:00,160 --> 00:31:57,950
earth taken from a very great distance

913
00:32:04,330 --> 00:32:00,170

to help them out with their analysis as

914
00:32:06,130 --> 00:32:04,340
well using the VPL earth model so that's

915
00:32:07,570 --> 00:32:06,140
the earth so if we move on to task de

916
00:32:09,370 --> 00:32:07,580
the earth through time

917
00:32:12,340 --> 00:32:09,380
so here again we care about the earth

918
00:32:13,870 --> 00:32:12,350
through time because for 50 percent of

919
00:32:17,230 --> 00:32:13,880
the Earth's history we didn't have

920
00:32:19,330 --> 00:32:17,240
oxygen 'ok photosynthesis dominating the

921
00:32:22,300 --> 00:32:19,340
the atmospheric composition of this

922
00:32:24,460 --> 00:32:22,310
planet we had other biospheres and other

923
00:32:25,990 --> 00:32:24,470
potential bio signatures and in trying

924
00:32:28,030 --> 00:32:26,000
to understand those with the existing

925
00:32:29,620 --> 00:32:28,040
geological and biological records we can

926
00:32:31,660 --> 00:32:29,630
potentially get a handle on what we

927
00:32:35,560 --> 00:32:31,670
might see on planets that have not yet

928
00:32:39,070 --> 00:32:35,570
evolved and gone through an oxygen rise

929
00:32:41,200 --> 00:32:39,080
event as the earth did so the earth

930
00:32:42,790 --> 00:32:41,210
through time again combining couple

931
00:32:44,290 --> 00:32:42,800
climate and atmospheric chemistry models

932
00:32:46,150 --> 00:32:44,300
were also actually adding ocean models

933
00:32:47,800 --> 00:32:46,160
as well in this round and we hope to get

934
00:32:49,540 --> 00:32:47,810
out the climate and disk average spectra

935
00:32:53,920 --> 00:32:49,550
of terrestrial planets at several stages

936
00:32:55,330 --> 00:32:53,930
of evolution so what we do here we

937
00:32:57,130 --> 00:32:55,340
couple the climate chemistry ocean the

938
00:32:58,540 --> 00:32:57,140

ecosystem models we get our constraints

939
00:33:00,730 --> 00:32:58,550
from geological and biological records

940
00:33:01,570 --> 00:33:00,740
we are interested overall even though we

941
00:33:03,490 --> 00:33:01,580
haven't modeled all of these

942
00:33:05,140 --> 00:33:03,500
environments yet but we hope to we're

943
00:33:06,580 --> 00:33:05,150
interested in the D and the archean and

944
00:33:09,310 --> 00:33:06,590
proterozoic the Carboniferous and

945
00:33:10,750 --> 00:33:09,320
snowball events and also looking at the

946
00:33:13,360 --> 00:33:10,760
future earth what that would look like

947
00:33:14,950 --> 00:33:13,370
as well and from that we hope to get

948
00:33:17,560 --> 00:33:14,960
spectra restful planets a different

949
00:33:19,330 --> 00:33:17,570
stages of development so our current

950
00:33:21,070 --> 00:33:19,340
projects are looking at the effects of

951
00:33:22,990 --> 00:33:21,080
enhanced volcanic sulfur gases we can

952
00:33:25,630 --> 00:33:23,000
have a software focus at the moment on

953
00:33:27,279 --> 00:33:25,640
both early Mars and early Earth we're

954
00:33:29,019 --> 00:33:27,289
looking at methane greenhouses in the

955
00:33:30,549 --> 00:33:29,029
Archaean trying to warm the early Earth

956
00:33:34,060 --> 00:33:30,559
and trying to understand what kept this

957
00:33:36,190 --> 00:33:34,070
planet habitable I'm over that time we

958
00:33:38,590 --> 00:33:36,200
also look at the haze implications for a

959
00:33:40,510 --> 00:33:38,600
software myth in the Archaean to look at

960
00:33:42,940 --> 00:33:40,520
the behavior of sulfur myth with haze in

961
00:33:45,279 --> 00:33:42,950
place some of our colleagues here at the

962
00:33:46,930 --> 00:33:45,289
Udo we're working on on actual using

963
00:33:48,730 --> 00:33:46,940

geological constraints to get our key

964
00:33:50,620 --> 00:33:48,740
and atmospheric pressure to be very

965
00:33:52,720 --> 00:33:50,630
exciting if that pans out so we're

966
00:33:55,930 --> 00:33:52,730
looking forward to those results we have

967
00:33:58,330 --> 00:33:55,940
people modeling microbial mats and also

968
00:33:59,919 --> 00:33:58,340
at Cal Tech Yeo Kyung and John Rogan

969
00:34:02,200 --> 00:33:59,929
virgin green are working on Earth's

970
00:34:04,750 --> 00:34:02,210
ecological sensitivity through the 21st

971
00:34:07,539 --> 00:34:04,760
century looking at the rise of carbon

972
00:34:09,070 --> 00:34:07,549
dioxide and climate change overall so

973
00:34:10,810 --> 00:34:09,080
our future projects include finishing

974
00:34:12,669 --> 00:34:10,820
off pretty much all of the above and

975
00:34:14,609 --> 00:34:12,679
also looking at the rise of oxygen with

976
00:34:16,810 --> 00:34:14,619
time-dependent photochemical models

977
00:34:19,030 --> 00:34:16,820
developing a coupled atmosphere ocean

978
00:34:20,649 --> 00:34:19,040
model for the Archean which is I think

979
00:34:23,290 --> 00:34:20,659
being led at the moment by Sean Sean

980
00:34:25,510 --> 00:34:23,300
Goldman with mark Clair and also Watson

981
00:34:28,720 --> 00:34:25,520
Greta Craig at Goddard and Kevin's Omni

982
00:34:30,310 --> 00:34:28,730
at Ames involved in that too and also

983
00:34:32,680 --> 00:34:30,320
team members looking at managing

984
00:34:34,720 --> 00:34:32,690
productivity for the Archaean and other

985
00:34:37,389 --> 00:34:34,730
collaboration between Ames u-dub and

986
00:34:38,980 --> 00:34:37,399
Penn State on that one so I'm just going

987
00:34:42,190 --> 00:34:38,990
to go through a specific example here of

988
00:34:43,780 --> 00:34:42,200

what we do for the early Earth so this

989
00:34:45,970 --> 00:34:43,790
is this is work that has been done but

990
00:34:48,490 --> 00:34:45,980
it demonstrates very nicely how we can

991
00:34:50,190 --> 00:34:48,500
use models to help understand the

992
00:34:54,520 --> 00:34:50,200
environment indeed

993
00:34:56,139 --> 00:34:54,530
excuse me in the context of geological

994
00:34:57,880 --> 00:34:56,149
and biological constraints as well so

995
00:34:59,290 --> 00:34:57,890
there's interplay between what we can

996
00:35:03,430 --> 00:34:59,300
learn from the field and the modeling

997
00:35:06,550 --> 00:35:03,440
efforts so this group led by Jacob park

998
00:35:09,130 --> 00:35:06,560
misra and also Sean on some aspects of

999
00:35:11,070 --> 00:35:09,140
this Rondo mobile Goldman so this is a

1000
00:35:14,050 --> 00:35:11,080
collaboration between vpl and Penn State

1001
00:35:16,420 --> 00:35:14,060
looking at prior to the rise of oxygen

1002
00:35:18,339 --> 00:35:16,430
we know that the early Earth appears to

1003
00:35:19,870 --> 00:35:18,349
have been ice-free even though the

1004
00:35:21,820 --> 00:35:19,880
astronomers tell us that the Sun was

1005
00:35:23,829 --> 00:35:21,830
much much fainter at that time so people

1006
00:35:26,290 --> 00:35:23,839
been trying to warm the early Earth this

1007
00:35:28,210 --> 00:35:26,300
study looked at novel things to warm the

1008
00:35:30,430 --> 00:35:28,220
early Earth methane

1009
00:35:33,130 --> 00:35:30,440
which may be considered to be maybe not

1010
00:35:35,170 --> 00:35:33,140
so novel but also things like ethane and

1011
00:35:36,550 --> 00:35:35,180
higher hydrocarbons and also looking at

1012
00:35:38,140 --> 00:35:36,560
the effect of adding these sorts of

1013
00:35:39,819 --> 00:35:38,150

hydrocarbons into the atmosphere sure

1014
00:35:41,890 --> 00:35:39,829
you get greenhouse warming but you may

1015
00:35:43,780 --> 00:35:41,900
also potentially produce a haze and what

1016
00:35:44,620 --> 00:35:43,790
happens when you produce haze on this

1017
00:35:46,720 --> 00:35:44,630
type of planet

1018
00:35:50,069 --> 00:35:46,730
so haze formation can occur for a

1019
00:35:52,630 --> 00:35:50,079
methane to co2 ratio of about 1 or less

1020
00:35:54,520 --> 00:35:52,640
if the haze is thin it provides a very

1021
00:35:56,890 --> 00:35:54,530
nice UV shield and may in fact affect

1022
00:35:58,900 --> 00:35:56,900
your yourself amid signature but if the

1023
00:36:01,180 --> 00:35:58,910
haze is very thick it produces an anti

1024
00:36:03,130 --> 00:36:01,190
greenhouse effect by shielding the

1025
00:36:05,470 --> 00:36:03,140
surface of the planet from incoming

1026
00:36:07,030 --> 00:36:05,480
sunlight and so that actually cools your

1027
00:36:08,500 --> 00:36:07,040
planet rather than warming it so there

1028
00:36:10,300 --> 00:36:08,510
is this interplay between adding new

1029
00:36:12,000 --> 00:36:10,310
greenhouse gases and trying to avoid the

1030
00:36:14,109 --> 00:36:12,010
formation of a thick haze for warming

1031
00:36:15,819 --> 00:36:14,119
since the haze thickness will actually

1032
00:36:18,670 --> 00:36:15,829
depend on with antigen activity in the

1033
00:36:21,250 --> 00:36:18,680
early Earth and co2 levels it's possible

1034
00:36:22,510 --> 00:36:21,260
the qiyan haze is also mediated by life

1035
00:36:25,450 --> 00:36:22,520
so that was another focus of this

1036
00:36:27,280 --> 00:36:25,460
exploration this project uses planet

1037
00:36:28,809 --> 00:36:27,290
models founded by geological constraints

1038
00:36:30,790 --> 00:36:28,819

on atmospheric composition so it uses

1039
00:36:32,770 --> 00:36:30,800
photo chemistry models as well and

1040
00:36:34,930 --> 00:36:32,780
temperature to better constrain

1041
00:36:37,329 --> 00:36:34,940
conditions on the early Earth so this is

1042
00:36:39,760 --> 00:36:37,339
kind of a case example so just to show

1043
00:36:42,160 --> 00:36:39,770
you some of the results from this these

1044
00:36:45,400 --> 00:36:42,170
are plots of surface temperature versus

1045
00:36:47,109 --> 00:36:45,410
co2 pressure what we're trying to do is

1046
00:36:50,170 --> 00:36:47,119
get above this blue line this blue line

1047
00:36:52,120 --> 00:36:50,180
is freezing so we would like you know

1048
00:36:53,920 --> 00:36:52,130
our results to be somewhere above this

1049
00:36:56,500 --> 00:36:53,930
blue line and we would also like them if

1050
00:36:58,900 --> 00:36:56,510
possible to be to the left of this

1051
00:37:02,440 --> 00:36:58,910
parasol data line because this is kind

1052
00:37:03,940 --> 00:37:02,450
of the the hard limit for the amount of

1053
00:37:07,770 --> 00:37:03,950
co2 that we think is in the atmosphere

1054
00:37:10,329 --> 00:37:07,780
based on paleo salt data so if we

1055
00:37:12,069 --> 00:37:10,339
consider those constraints then the

1056
00:37:13,480 --> 00:37:12,079
results show that if you add methane

1057
00:37:16,200 --> 00:37:13,490
into the atmosphere you can really only

1058
00:37:18,460 --> 00:37:16,210
get above the surface temperature of a

1059
00:37:20,349 --> 00:37:18,470
freezing surface temperature and be

1060
00:37:22,030 --> 00:37:20,359
consistent with the Paleo Seoul data for

1061
00:37:24,910 --> 00:37:22,040
a relatively small part of that phase

1062
00:37:26,650 --> 00:37:24,920
diagram so methane may not be the best

1063
00:37:28,960 --> 00:37:26,660

solution on its own to this particular

1064
00:37:30,579 --> 00:37:28,970
problem so the other thing this team

1065
00:37:31,930 --> 00:37:30,589
looked at was well ok there are other

1066
00:37:34,120 --> 00:37:31,940
hydrocarbons in the atmosphere they can

1067
00:37:36,490 --> 00:37:34,130
also be potentially greenhouse gases in

1068
00:37:37,150 --> 00:37:36,500
this photochemical model and showing

1069
00:37:39,220 --> 00:37:37,160
that in fact

1070
00:37:41,799 --> 00:37:39,230
ethane may be one of the most abundant

1071
00:37:42,999 --> 00:37:41,809
of these gases so this

1072
00:37:44,949 --> 00:37:43,009
would be the next one to consider for

1073
00:37:47,079 --> 00:37:44,959
greenhouse warming so the team ran the

1074
00:37:49,839 --> 00:37:47,089
models with both methane and ethane in

1075
00:37:51,609 --> 00:37:49,849
and in fact found that they were able to

1076
00:37:53,109 --> 00:37:51,619
get solutions over a larger range in the

1077
00:37:54,999 --> 00:37:53,119
phase space that justified both the

1078
00:37:56,620 --> 00:37:55,009
geological constraints and it's not

1079
00:37:59,709 --> 00:37:56,630
freezing on the surface requirement

1080
00:38:01,329 --> 00:37:59,719
however there's a consequence to adding

1081
00:38:02,529 --> 00:38:01,339
large amounts of methane and co2 into

1082
00:38:04,449 --> 00:38:02,539
your atmosphere and that is the

1083
00:38:07,359 --> 00:38:04,459
formation of haze and so what this

1084
00:38:09,819 --> 00:38:07,369
diagram shows in the red line is if you

1085
00:38:12,880 --> 00:38:09,829
just ignore haze production then as you

1086
00:38:14,469 --> 00:38:12,890
increase the methane to co2 ratio you

1087
00:38:15,670 --> 00:38:14,479
end up with consistent warming of the

1088
00:38:17,799 --> 00:38:15,680

surface of the atmosphere that's where

1089
00:38:19,689 --> 00:38:17,809
that red line continues to go up however

1090
00:38:21,370 --> 00:38:19,699
in reality reality looks a lot more like

1091
00:38:24,339 --> 00:38:21,380
the blue line and that is that as you

1092
00:38:26,559 --> 00:38:24,349
increase the methane to co2 ratio you in

1093
00:38:30,130 --> 00:38:26,569
fact produce haze fairly rapidly after

1094
00:38:31,989 --> 00:38:30,140
an array shio of about 0.1 and that haze

1095
00:38:33,459 --> 00:38:31,999
overall will decrease the surface

1096
00:38:36,519 --> 00:38:33,469
temperature that's that blue dropping

1097
00:38:38,529 --> 00:38:36,529
line and increase the extinction of the

1098
00:38:41,259 --> 00:38:38,539
of the haze and that's like the Green

1099
00:38:43,209 --> 00:38:41,269
Line increasing so even though you count

1100
00:38:45,099 --> 00:38:43,219
on the the greenhouse warming if you get

1101
00:38:47,319 --> 00:38:45,109
haze reduction you end up with a net

1102
00:38:49,449 --> 00:38:47,329
cooling because of this ANSI greenhouse

1103
00:38:52,029 --> 00:38:49,459
effect so if we now look at the

1104
00:38:54,309 --> 00:38:52,039
solutions with methane ethane and the

1105
00:38:55,989 --> 00:38:54,319
haze in place it turns out that none of

1106
00:38:57,279 --> 00:38:55,999
our potential solutions those black

1107
00:39:00,729 --> 00:38:57,289
lines actually fall within that

1108
00:39:03,969 --> 00:39:00,739
desirable region which means that we

1109
00:39:06,309 --> 00:39:03,979
really do have to invoke stretching the

1110
00:39:07,949 --> 00:39:06,319
parasol data given the errors from that

1111
00:39:10,959 --> 00:39:07,959
particular measurement stretching it out

1112
00:39:12,699 --> 00:39:10,969
to to higher limits and if that were the

1113
00:39:15,039 --> 00:39:12,709

case then we could end up with in fact a

1114
00:39:18,609 --> 00:39:15,049
self-consistent our solution with both

1115
00:39:20,439 --> 00:39:18,619
methane and co2 as greenhouse gases with

1116
00:39:23,109 --> 00:39:20,449
their attendant haze in place but it

1117
00:39:24,789 --> 00:39:23,119
does require that we don't take the sort

1118
00:39:27,339 --> 00:39:24,799
of classic Paleo saw limit but really

1119
00:39:30,489 --> 00:39:27,349
push it to to the era of the aero limits

1120
00:39:33,429 --> 00:39:30,499
of that particular measurement so in

1121
00:39:35,529 --> 00:39:33,439
summary for that particular effort we

1122
00:39:38,349 --> 00:39:35,539
found that water co2 and methane alone

1123
00:39:40,179 --> 00:39:38,359
really can't easily warm the earlier kin

1124
00:39:41,739 --> 00:39:40,189
we've looked at things like adding

1125
00:39:43,809 --> 00:39:41,749
ethane that seems to help but maybe

1126
00:39:45,459 --> 00:39:43,819
doesn't get us all the way but they but

1127
00:39:47,079 --> 00:39:45,469
the team has also realistically looked

1128
00:39:49,719 --> 00:39:47,089
at the effects of adding co2 and methane

1129
00:39:52,390 --> 00:39:49,729
and the haze that gets produced and this

1130
00:39:54,010 --> 00:39:52,400
potential anti greenhouse effect so we

1131
00:39:56,110 --> 00:39:54,020
do require if this

1132
00:39:57,730 --> 00:39:56,120
mechanisms going to work actually more

1133
00:40:01,150 --> 00:39:57,740
than this paleo soul limit a point of

1134
00:40:03,130 --> 00:40:01,160
three bars of co2 and ultimately also

1135
00:40:04,330 --> 00:40:03,140
looking at this problem the researchers

1136
00:40:05,560 --> 00:40:04,340
realized that the climate stability in

1137
00:40:07,030 --> 00:40:05,570
the archein could have been maintained

1138
00:40:09,040 --> 00:40:07,040

by the response of management production

1139
00:40:11,020 --> 00:40:09,050
to surface temperature and so that's

1140
00:40:13,800 --> 00:40:11,030
going to be the focus of a future effort

1141
00:40:15,850 --> 00:40:13,810
as well in this area is looking into

1142
00:40:17,710 --> 00:40:15,860
quantifying with antigen production

1143
00:40:21,820 --> 00:40:17,720
overall to better understand that

1144
00:40:23,620 --> 00:40:21,830
potential feedback in the Aegean so that

1145
00:40:24,730 --> 00:40:23,630
was tasked me with an example again

1146
00:40:26,260 --> 00:40:24,740
which I mean a lot there I just showed

1147
00:40:27,730 --> 00:40:26,270
one particular example of things that

1148
00:40:30,280 --> 00:40:27,740
have been done um

1149
00:40:32,230 --> 00:40:30,290
so task C as what we call the habitable

1150
00:40:35,380 --> 00:40:32,240
planet so this is our abiotic planet

1151
00:40:37,120 --> 00:40:35,390
model it doesn't include an explicit

1152
00:40:38,920 --> 00:40:37,130
biosphere in it it really is just us

1153
00:40:40,750 --> 00:40:38,930
trying to understand how habitable

1154
00:40:43,120 --> 00:40:40,760
planets form how they might maintain

1155
00:40:45,670 --> 00:40:43,130
habitability and looking at the kind of

1156
00:40:48,460 --> 00:40:45,680
processes and interactions that occur on

1157
00:40:50,200 --> 00:40:48,470
these types of planets so ultimately

1158
00:40:52,060 --> 00:40:50,210
with this model we hope to have a couple

1159
00:40:54,670 --> 00:40:52,070
climate photochemical model that will

1160
00:40:57,610 --> 00:40:54,680
allow us to model planets of different

1161
00:40:59,800 --> 00:40:57,620
type not just earth-like planets to get

1162
00:41:02,770 --> 00:40:59,810
us disc Everage spectra climate and to

1163
00:41:05,070 --> 00:41:02,780

also explode the limits of the habitable

1164
00:41:07,870 --> 00:41:05,080
zone for plausible extrasolar planets

1165
00:41:09,130 --> 00:41:07,880
the current projects include habitable

1166
00:41:10,450 --> 00:41:09,140
terrestrial planet formation and

1167
00:41:12,310 --> 00:41:10,460
Composition which have been worked on by

1168
00:41:15,190 --> 00:41:12,320
sean raymond monica cress and rory

1169
00:41:18,520 --> 00:41:15,200
barnes there at Colorado or San Jose

1170
00:41:19,810 --> 00:41:18,530
State and University of Washington were

1171
00:41:22,060 --> 00:41:19,820
warming early Mars trying different

1172
00:41:25,720 --> 00:41:22,070
types of gases to do that to get it

1173
00:41:27,670 --> 00:41:25,730
habitable looking at so2 and early Mars

1174
00:41:30,250 --> 00:41:27,680
so2 has been postulated as a way to warm

1175
00:41:31,930 --> 00:41:30,260
early Mars but more work needs to be

1176
00:41:34,060 --> 00:41:31,940
done on the actual photochemical and

1177
00:41:35,230 --> 00:41:34,070
climate consequences of adding so2 to

1178
00:41:36,640 --> 00:41:35,240
the atmosphere which haven't been really

1179
00:41:39,310 --> 00:41:36,650
fully modeled through so we're looking

1180
00:41:41,860 --> 00:41:39,320
at that that's a DDF project by the way

1181
00:41:44,410 --> 00:41:41,870
that was funded Thank You Carl a

1182
00:41:45,790 --> 00:41:44,420
habitable zone limits as well we're

1183
00:41:48,010 --> 00:41:45,800
attacking that two ways we're using

1184
00:41:49,870 --> 00:41:48,020
three dimensional models and we're also

1185
00:41:51,130 --> 00:41:49,880
starting out with one dimensional models

1186
00:41:53,170 --> 00:41:51,140
and here we're really looking at the

1187
00:41:56,470 --> 00:41:53,180
realistic effect of clouds and these

1188
00:41:58,020 --> 00:41:56,480

hazers on the climate bounce of planets

1189
00:42:00,700 --> 00:41:58,030
near the limits of the habitable zone

1190
00:42:02,200 --> 00:42:00,710
and in addition to just looking at the

1191
00:42:04,180 --> 00:42:02,210
radiative effects on the habitable zone

1192
00:42:06,250 --> 00:42:04,190
it turns out that for planets around M

1193
00:42:07,840 --> 00:42:06,260
stars the habitable zone the reason

1194
00:42:09,970 --> 00:42:07,850
where the region where they can

1195
00:42:11,800 --> 00:42:09,980
the liquid water on the surface is very

1196
00:42:13,690 --> 00:42:11,810
close to the parent star and that means

1197
00:42:15,340 --> 00:42:13,700
that the star starts to gravitationally

1198
00:42:16,930 --> 00:42:15,350
interact with the planet in addition to

1199
00:42:18,850 --> 00:42:16,940
radiatively interacting with the planet

1200
00:42:20,350 --> 00:42:18,860
so what that means is the star can

1201
00:42:22,840 --> 00:42:20,360
actually transfer gravitational energy

1202
00:42:24,730 --> 00:42:22,850
into tidal heating of the planet the way

1203
00:42:27,310 --> 00:42:24,740
IO gets heated by Jupiter for example

1204
00:42:29,230 --> 00:42:27,320
and so you can affect drive geology and

1205
00:42:30,700 --> 00:42:29,240
geological cycles by a gravitational

1206
00:42:31,660 --> 00:42:30,710
interaction with the parent star and

1207
00:42:34,450 --> 00:42:31,670
we're looking at how that affects

1208
00:42:35,800 --> 00:42:34,460
habitability also we also have these

1209
00:42:37,120 --> 00:42:35,810
super earth environments that were

1210
00:42:38,680 --> 00:42:37,130
particularly interested in everybody's

1211
00:42:40,960 --> 00:42:38,690
interested in super Earths these are the

1212
00:42:42,400 --> 00:42:40,970
very largest of the earth-like planets

1213
00:42:45,370 --> 00:42:42,410

that have been found so far so if things

1214
00:42:46,660 --> 00:42:45,380
at about eight Earth masses these are

1215
00:42:48,730 --> 00:42:46,670
observational things that are being

1216
00:42:51,520 --> 00:42:48,740
found now and will be found and explored

1217
00:42:53,020 --> 00:42:51,530
relatively soon so we also would like to

1218
00:42:54,400 --> 00:42:53,030
get into modeling super earth

1219
00:42:56,170 --> 00:42:54,410
environments and trying to understand

1220
00:42:57,940 --> 00:42:56,180
their composition climate balance and

1221
00:43:00,940 --> 00:42:57,950
also potentially that the geological

1222
00:43:02,230 --> 00:43:00,950
activity associated with them so future

1223
00:43:04,240 --> 00:43:02,240
projects in this area are getting that

1224
00:43:04,840 --> 00:43:04,250
one D climate chemical model working for

1225
00:43:07,360 --> 00:43:04,850
super Earths

1226
00:43:09,580 --> 00:43:07,370
I'm led by ty Robinson and also 3d

1227
00:43:11,800 --> 00:43:09,590
environmental modeling as well and just

1228
00:43:17,230 --> 00:43:11,810
in in the general area getting

1229
00:43:18,760 --> 00:43:17,240
generalized models for these two so I'm

1230
00:43:19,780 --> 00:43:18,770
not sure I'm going I'm sort of running

1231
00:43:21,220 --> 00:43:19,790
out of time here is I'm actually going

1232
00:43:22,630 --> 00:43:21,230
to skip this a little bit this is work

1233
00:43:24,730 --> 00:43:22,640
done by Monica cress where she's

1234
00:43:27,040 --> 00:43:24,740
actually working on how to get solid

1235
00:43:28,990 --> 00:43:27,050
carbon into planets as they form working

1236
00:43:31,000 --> 00:43:29,000
on this concept of the soot line she

1237
00:43:32,800 --> 00:43:31,010
thinks PAHs are probably the most likely

1238
00:43:36,250 --> 00:43:32,810

way that carbon gets incorporated into a

1239
00:43:37,810 --> 00:43:36,260
forming planet and she is producing disk

1240
00:43:40,830 --> 00:43:37,820
chemistry models which we show here that

1241
00:43:43,060 --> 00:43:40,840
actually show the evolution of these

1242
00:43:44,500 --> 00:43:43,070
constituents with radial distance from

1243
00:43:46,900 --> 00:43:44,510
the center of the star and a planet

1244
00:43:49,390 --> 00:43:46,910
forming disk and we are combining these

1245
00:43:50,950 --> 00:43:49,400
results with showing Ramon's planet

1246
00:43:54,430 --> 00:43:50,960
formation models to actually get a much

1247
00:43:56,110 --> 00:43:54,440
better idea of the bulk composition of

1248
00:43:57,820 --> 00:43:56,120
planets once they form in a particular

1249
00:44:00,510 --> 00:43:57,830
simulation so the combination of

1250
00:44:02,260 --> 00:44:00,520
chemistry and planet formation models

1251
00:44:04,570 --> 00:44:02,270
the other thing we're looking at

1252
00:44:06,700 --> 00:44:04,580
problems were the inner solar system and

1253
00:44:08,140 --> 00:44:06,710
accretion a short name is trying to

1254
00:44:10,540 --> 00:44:08,150
create Mars but he's having trouble

1255
00:44:12,610 --> 00:44:10,550
whenever he manages to get a Mars that

1256
00:44:14,110 --> 00:44:12,620
is small enough means he has to put some

1257
00:44:15,540 --> 00:44:14,120
unrealistic constraints on the outer

1258
00:44:17,680 --> 00:44:15,550
solar system including

1259
00:44:19,680 --> 00:44:17,690
Jupiter's and Saturn's with eccentric

1260
00:44:21,660 --> 00:44:19,690
orbits and

1261
00:44:22,770 --> 00:44:21,670
non migrating bodies mini Neptune isn't

1262
00:44:25,140 --> 00:44:22,780
allowed to migrate which we know

1263
00:44:27,030 --> 00:44:25,150

actually happens but in the process he's

1264
00:44:29,130 --> 00:44:27,040
severing that if he if he can if he

1265
00:44:31,500 --> 00:44:29,140
creates and Mars he actually dries out

1266
00:44:32,670 --> 00:44:31,510
the inner solar system so again we're

1267
00:44:34,440 --> 00:44:32,680
trying to understand the delivery of

1268
00:44:36,720 --> 00:44:34,450
volatiles and also just the creation of

1269
00:44:39,390 --> 00:44:36,730
the own planets in our own planetary

1270
00:44:41,640 --> 00:44:39,400
system another thing Shawn is working on

1271
00:44:43,020 --> 00:44:41,650
is models of how you create hot super

1272
00:44:44,550 --> 00:44:43,030
Earths we've had some super Earths

1273
00:44:46,230 --> 00:44:44,560
discovered very very close to their

1274
00:44:47,790 --> 00:44:46,240
parent star he's trying to figure out

1275
00:44:49,530 --> 00:44:47,800
how they got there whether they migrated

1276
00:44:52,620 --> 00:44:49,540
there got shepherded in by a giant

1277
00:44:54,150 --> 00:44:52,630
planet formed in situ so his models have

1278
00:44:55,859 --> 00:44:54,160
been used to then predict what these

1279
00:44:58,230 --> 00:44:55,869
planets would be like their composition

1280
00:44:59,730 --> 00:44:58,240
where you might find them what kind of

1281
00:45:01,859 --> 00:44:59,740
dynamical characteristics they would

1282
00:45:04,680 --> 00:45:01,869
have in those particular positions and

1283
00:45:05,910 --> 00:45:04,690
so he's come down with two models that

1284
00:45:07,790 --> 00:45:05,920
he think are the best ones who are

1285
00:45:10,079 --> 00:45:07,800
creating hot earths and they have

1286
00:45:12,630 --> 00:45:10,089
observable consequences so we're waiting

1287
00:45:14,339 --> 00:45:12,640
for Perot and Kepler to maybe look at

1288
00:45:16,410 --> 00:45:14,349

these systems and tell us whether or not

1289
00:45:18,599 --> 00:45:16,420
at least one of these models was right

1290
00:45:21,150 --> 00:45:18,609
so again predictions with models and

1291
00:45:22,980 --> 00:45:21,160
this is just a quick diagram showing

1292
00:45:24,720 --> 00:45:22,990
Rory Barnes's work on this tidally

1293
00:45:26,309 --> 00:45:24,730
heated habitable zone the concept that

1294
00:45:27,599 --> 00:45:26,319
it's not just the radiation hitting the

1295
00:45:29,849 --> 00:45:27,609
surface of the planet that's important

1296
00:45:33,540 --> 00:45:29,859
but also the gravitational energy being

1297
00:45:35,910 --> 00:45:33,550
deposited and so he's looking overall at

1298
00:45:38,339 --> 00:45:35,920
when you can get enough heating from

1299
00:45:40,170 --> 00:45:38,349
tidal heating to to actually contribute

1300
00:45:43,440 --> 00:45:40,180
to the habitability planet and when you

1301
00:45:47,640 --> 00:45:43,450
get too much and actually drive the loss

1302
00:45:50,940 --> 00:45:47,650
of habitat for the planet that task D

1303
00:45:53,069 --> 00:45:50,950
the living planet in this particular one

1304
00:45:54,720 --> 00:45:53,079
we actually start using biospheres to

1305
00:45:57,660 --> 00:45:54,730
understand the interaction between life

1306
00:45:59,940 --> 00:45:57,670
and the environment current and future

1307
00:46:01,650 --> 00:45:59,950
projects we're working on these the

1308
00:46:03,300 --> 00:46:01,660
responsive inhabited planet atmospheres

1309
00:46:05,849 --> 00:46:03,310
to time-dependent stellar flare activity

1310
00:46:07,589 --> 00:46:05,859
so not only do we rip our Sun out and

1311
00:46:09,089 --> 00:46:07,599
replace it with an M star do we replace

1312
00:46:12,390 --> 00:46:09,099
it with an M star that is flaring

1313
00:46:14,990 --> 00:46:12,400

massively is undergoing a rapid and

1314
00:46:18,329 --> 00:46:15,000
violent release of ultraviolet radiation

1315
00:46:20,460 --> 00:46:18,339
looking at how that in fact affects the

1316
00:46:21,960 --> 00:46:20,470
habitability of the surface we've been

1317
00:46:23,849 --> 00:46:21,970
looking at bio signatures from self

1318
00:46:25,440 --> 00:46:23,859
advised finished signal sorry self

1319
00:46:27,720 --> 00:46:25,450
advisory is in the Archaean trying to

1320
00:46:29,309 --> 00:46:27,730
understand different metabolisms and not

1321
00:46:31,740 --> 00:46:29,319
just sticking with our oxygen okoto

1322
00:46:33,480 --> 00:46:31,750
synthesis we've looked at the

1323
00:46:34,920 --> 00:46:33,490
coevolution of photosynthetic

1324
00:46:37,020 --> 00:46:34,930
with the environment and some people may

1325
00:46:38,730 --> 00:46:37,030
remember this this was a press release

1326
00:46:40,800 --> 00:46:38,740
and also a scientific American article

1327
00:46:43,590 --> 00:46:40,810
on understanding the colors of planets

1328
00:46:45,240 --> 00:46:43,600
sorry colors of plants on other planets

1329
00:46:47,400 --> 00:46:45,250
I'll talk a little bit about that in

1330
00:46:49,530 --> 00:46:47,410
more detail and also lab work on the

1331
00:46:51,690 --> 00:46:49,540
efficiency of photosynthesis and also

1332
00:46:53,370 --> 00:46:51,700
development of land and ocean by stroke

1333
00:46:54,870 --> 00:46:53,380
models so I'm just going to go over each

1334
00:46:57,240 --> 00:46:54,880
of these with one slide just a little

1335
00:46:59,790 --> 00:46:57,250
bit more detail yes and of course I feel

1336
00:47:03,270 --> 00:46:59,800
modeling components led by pan Conrad

1337
00:47:05,190 --> 00:47:03,280
it's Lombard and Janet Seaford - Quatro

1338
00:47:07,320 --> 00:47:05,200

Cienega s-- and I know that the Quatro

1339
00:47:07,890 --> 00:47:07,330
Cienega study is also in collaboration

1340
00:47:11,040 --> 00:47:07,900
with ASU

1341
00:47:14,609 --> 00:47:11,050
as well so there we look at the limits

1342
00:47:16,290 --> 00:47:14,619
of habitability and also stromatolite

1343
00:47:18,270 --> 00:47:16,300
fresh waters from Adelaide growth in

1344
00:47:19,590 --> 00:47:18,280
potassium deficient environments again

1345
00:47:21,450 --> 00:47:19,600
understanding these primitive life

1346
00:47:24,030 --> 00:47:21,460
wounds to see how they might impact our

1347
00:47:25,800 --> 00:47:24,040
early Earth environments so with a

1348
00:47:27,570 --> 00:47:25,810
stellar florist and habitability what we

1349
00:47:29,310 --> 00:47:27,580
did was again we used a couple climate

1350
00:47:31,740 --> 00:47:29,320
chemical model that we modified it to be

1351
00:47:33,540 --> 00:47:31,750
able to take him time-dependent stellar

1352
00:47:35,640 --> 00:47:33,550
forcings that meant we could change the

1353
00:47:39,660 --> 00:47:35,650
spectrum of the star every 10 seconds

1354
00:47:41,730 --> 00:47:39,670
have that feed into the into the climate

1355
00:47:43,650 --> 00:47:41,740
chemistry model and look at the effect

1356
00:47:45,660 --> 00:47:43,660
on the photochemistry of the planet as

1357
00:47:47,849 --> 00:47:45,670
it was being bombarded by ultraviolet

1358
00:47:49,410 --> 00:47:47,859
radiation from this star so to do this

1359
00:47:50,340 --> 00:47:49,420
project we had to collaborate with real

1360
00:47:51,330 --> 00:47:50,350
honest-to-goodness stellar

1361
00:47:53,070 --> 00:47:51,340
astrophysicists

1362
00:47:54,300 --> 00:47:53,080
who could tell us you know what the

1363
00:47:56,490 --> 00:47:54,310

sweat from the star was like and how

1364
00:47:58,170 --> 00:47:56,500
that evolved over time and then we put

1365
00:47:59,310 --> 00:47:58,180
that as input into our climate chemical

1366
00:48:01,890 --> 00:47:59,320
model to look at the effects on

1367
00:48:03,990 --> 00:48:01,900
temperature ozone cone depth and surface

1368
00:48:05,790 --> 00:48:04,000
and UV flux and what we found was

1369
00:48:07,920 --> 00:48:05,800
actually kind of interesting and that

1370
00:48:09,750 --> 00:48:07,930
was that in fact even when we hit a

1371
00:48:13,890 --> 00:48:09,760
planet with one of the worst flares that

1372
00:48:14,280 --> 00:48:13,900
an M star can put out that 10 to the 32

1373
00:48:16,470 --> 00:48:14,290
ergs

1374
00:48:18,150 --> 00:48:16,480
we got a less than 1% change in the

1375
00:48:21,420 --> 00:48:18,160
overall ozone calm depths that was

1376
00:48:23,070 --> 00:48:21,430
actually very robust to that I'm during

1377
00:48:27,120 --> 00:48:23,080
and after the flare and in fact you can

1378
00:48:28,980 --> 00:48:27,130
see that over time we in fact reached

1379
00:48:31,349 --> 00:48:28,990
our equilibrium position after several

1380
00:48:32,790 --> 00:48:31,359
months so that really was a perturbation

1381
00:48:35,430 --> 00:48:32,800
to the atmosphere over several months

1382
00:48:37,260 --> 00:48:35,440
after the flare but that was in fact a

1383
00:48:39,230 --> 00:48:37,270
pretty small is it the less than 1%

1384
00:48:42,420 --> 00:48:39,240
level and even at the peak of the flare

1385
00:48:43,920 --> 00:48:42,430
we got only twice the typical surface UV

1386
00:48:46,020 --> 00:48:43,930
flux we see at the earth which is not

1387
00:48:46,599 --> 00:48:46,030
too terrible and it was predominantly in

1388
00:48:50,019 --> 00:48:46,609

the UV

1389
00:48:51,940 --> 00:48:50,029
which is not as DNA damaging and so

1390
00:48:53,680 --> 00:48:51,950
really it wasn't that much of a deal

1391
00:48:55,569 --> 00:48:53,690
which we were we were quite surprised at

1392
00:48:57,700 --> 00:48:55,579
but again at least we least you run

1393
00:48:59,680 --> 00:48:57,710
through the models other things we've

1394
00:49:00,970 --> 00:48:59,690
done is look at how bio signatures get

1395
00:49:02,950 --> 00:49:00,980
enhanced when you have a star of

1396
00:49:04,870 --> 00:49:02,960
different spectral type again the

1397
00:49:06,400 --> 00:49:04,880
different type of radiation coming into

1398
00:49:08,529 --> 00:49:06,410
the top of the atmosphere affects the

1399
00:49:09,819 --> 00:49:08,539
lifetime of different constituents and

1400
00:49:11,859 --> 00:49:09,829
what we're just showing you very quickly

1401
00:49:14,589 --> 00:49:11,869
in this slide is that things like

1402
00:49:16,029 --> 00:49:14,599
methane for example can build up quite

1403
00:49:17,950 --> 00:49:16,039
significantly if you have a planet

1404
00:49:20,859 --> 00:49:17,960
around an M star this is less methane

1405
00:49:22,180 --> 00:49:20,869
this is more methane over here and these

1406
00:49:24,940 --> 00:49:22,190
different colors are the different types

1407
00:49:26,859 --> 00:49:24,950
of stars you can also build up more

1408
00:49:30,519 --> 00:49:26,869
nitrous oxide and more methyl chloride

1409
00:49:32,049 --> 00:49:30,529
but in fact what's not too apparent here

1410
00:49:34,450 --> 00:49:32,059
is a little bit subtle is that actually

1411
00:49:37,329 --> 00:49:34,460
methane and methyl chloride had rapid

1412
00:49:40,420 --> 00:49:37,339
increases in their lifetimes due to the

1413
00:49:42,549 --> 00:49:40,430

fact that ozone photolysis and oxygen

1414
00:49:44,109 --> 00:49:42,559
catalysis was not going on as well and

1415
00:49:45,970 --> 00:49:44,119
those are the pathways to getting rid of

1416
00:49:47,559 --> 00:49:45,980
methane and methyl chloride so those

1417
00:49:49,690 --> 00:49:47,569
weren't excited as much by the seller

1418
00:49:51,460 --> 00:49:49,700
spectrum but the nitrous oxide was

1419
00:49:53,200 --> 00:49:51,470
directly fertilized and it got hit much

1420
00:49:55,120 --> 00:49:53,210
harder it does have a longer lifetime

1421
00:49:56,950 --> 00:49:55,130
but it didn't enhance its lifetime

1422
00:49:58,690 --> 00:49:56,960
anywhere near as much as the methane and

1423
00:50:00,130 --> 00:49:58,700
their folklore I did so we're learning a

1424
00:50:03,549 --> 00:50:00,140
little bit more about what can build up

1425
00:50:06,779 --> 00:50:03,559
in a planetary atmosphere so here's a

1426
00:50:09,519 --> 00:50:06,789
spectrum of of the earth versus

1427
00:50:12,039 --> 00:50:09,529
different planets so a planet around a

1428
00:50:14,140 --> 00:50:12,049
dealio with and without methyl chloride

1429
00:50:15,519 --> 00:50:14,150
and all I want you to see here is in

1430
00:50:16,809 --> 00:50:15,529
fact the difference between the blue and

1431
00:50:19,059 --> 00:50:16,819
the red lines particularly in this

1432
00:50:21,130 --> 00:50:19,069
region is in fact absorption from methyl

1433
00:50:23,079 --> 00:50:21,140
chloride so that is another potential

1434
00:50:26,140 --> 00:50:23,089
bias signature we could look for on a

1435
00:50:27,640 --> 00:50:26,150
planet around a cooler star on the earth

1436
00:50:28,989 --> 00:50:27,650
the methyl chloride lifetime is

1437
00:50:30,640 --> 00:50:28,999
sufficiently short given the UV

1438
00:50:33,309 --> 00:50:30,650

radiation that's hitting our planet that

1439
00:50:35,079 --> 00:50:33,319
it doesn't build up to detectable levels

1440
00:50:36,910 --> 00:50:35,089
in the atmosphere around the earth

1441
00:50:38,529 --> 00:50:36,920
around the G star but if you have an

1442
00:50:40,870 --> 00:50:38,539
earth around an M star you start to be

1443
00:50:43,299 --> 00:50:40,880
able to detect things that are really

1444
00:50:44,589 --> 00:50:43,309
more traced in our own atmosphere the

1445
00:50:46,569 --> 00:50:44,599
other thing we looked at was also the

1446
00:50:49,450 --> 00:50:46,579
build-up again of sulfur biosignatures

1447
00:50:51,309 --> 00:50:49,460
on an early earth-type planet but again

1448
00:50:52,870 --> 00:50:51,319
around an M star and what we're looking

1449
00:50:55,390 --> 00:50:52,880
at here is the difference between the

1450
00:50:57,309 --> 00:50:55,400
black and the red line here this

1451
00:50:59,289 --> 00:50:57,319
particular slope in the red is actually

1452
00:51:00,320 --> 00:50:59,299
due to strong absorption from dimethyl

1453
00:51:02,660 --> 00:51:00,330
disulfide

1454
00:51:09,410 --> 00:51:02,670
in the atmosphere of the planet from a

1455
00:51:11,840 --> 00:51:09,420
sulphur biosphere so let's see code I'm

1456
00:51:13,640 --> 00:51:11,850
wrapping up here coevolution and

1457
00:51:15,230 --> 00:51:13,650
detection of alien photosynthesis was

1458
00:51:18,110 --> 00:51:15,240
something that Nancy Kang led which was

1459
00:51:21,230 --> 00:51:18,120
which was very exciting and this was

1460
00:51:23,240 --> 00:51:21,240
just looking at what type of radiation

1461
00:51:25,010 --> 00:51:23,250
hits the surface of the planet when we

1462
00:51:26,930 --> 00:51:25,020
do our modeling and we get our

1463
00:51:28,460 --> 00:51:26,940

environments and we generate spectra of

1464
00:51:29,780 --> 00:51:28,470
them we generate the kind of spectra

1465
00:51:31,130 --> 00:51:29,790
that would be coming off the top of the

1466
00:51:33,170 --> 00:51:31,140
atmosphere of the planet the sort of

1467
00:51:34,700 --> 00:51:33,180
thing that a telescope would see but as

1468
00:51:36,530 --> 00:51:34,710
a byproduct of all of these models we

1469
00:51:37,790 --> 00:51:36,540
also generate the radiation that's

1470
00:51:39,350 --> 00:51:37,800
actually hitting the surface of the

1471
00:51:41,780 --> 00:51:39,360
planet the sort of thing that a plant or

1472
00:51:44,030 --> 00:51:41,790
microbe would see looking up so Nancy

1473
00:51:45,410 --> 00:51:44,040
took this data she looked at it for

1474
00:51:47,630 --> 00:51:45,420
earth-like planets around different

1475
00:51:49,340 --> 00:51:47,640
types of stars at G K and M stars and

1476
00:51:51,200 --> 00:51:49,350
she figured out that in fact there were

1477
00:51:54,170 --> 00:51:51,210
some fundamental rules to where you

1478
00:51:57,230 --> 00:51:54,180
might expect photosynthetic pigments to

1479
00:51:58,700 --> 00:51:57,240
be and so working on those rules she was

1480
00:52:01,580 --> 00:51:58,710
able to essentially predict what the

1481
00:52:03,080 --> 00:52:01,590
colors of alien plants would be but one

1482
00:52:05,390 --> 00:52:03,090
thing we discovered in this is in fact

1483
00:52:07,850 --> 00:52:05,400
that the peak of chlorophyll a

1484
00:52:09,530 --> 00:52:07,860
absorption occurs at the peak of photon

1485
00:52:12,550 --> 00:52:09,540
flux incident on the surface of the

1486
00:52:15,110 --> 00:52:12,560
planet and that peak is at around 688

1487
00:52:16,880 --> 00:52:15,120
nanometers even though the peak of

1488
00:52:18,380 --> 00:52:16,890

energy coming from the star is in the

1489
00:52:19,880 --> 00:52:18,390
green you probably all learnt that you

1490
00:52:21,800 --> 00:52:19,890
know the most energy hitting the surface

1491
00:52:23,870 --> 00:52:21,810
of the planet isn't in green that's true

1492
00:52:24,890 --> 00:52:23,880
but the most number of photons is

1493
00:52:26,750 --> 00:52:24,900
actually in the red

1494
00:52:28,430 --> 00:52:26,760
and since photosynthesis is a photon

1495
00:52:30,020 --> 00:52:28,440
limited process that's where our plants

1496
00:52:32,270 --> 00:52:30,030
have decided they want to hang out and

1497
00:52:33,710 --> 00:52:32,280
get the photons so using these sorts of

1498
00:52:35,120 --> 00:52:33,720
rules she was able to predict where you

1499
00:52:36,590 --> 00:52:35,130
might expect to see photosynthetic

1500
00:52:40,430 --> 00:52:36,600
pigments on four planets

1501
00:52:41,690 --> 00:52:40,440
plants on other planets and she's

1502
00:52:43,340 --> 00:52:41,700
continuing that work by the way also

1503
00:52:45,680 --> 00:52:43,350
looking at what might drive the red edge

1504
00:52:48,290 --> 00:52:45,690
to the other thing now is he's working

1505
00:52:50,480 --> 00:52:48,300
on is the mother DDF effort again thank

1506
00:52:52,070 --> 00:52:50,490
you Carl is looking at the energetic

1507
00:52:54,440 --> 00:52:52,080
limit for water splitting for

1508
00:52:56,600 --> 00:52:54,450
photosynthesis so what Nancy and her

1509
00:52:59,390 --> 00:52:56,610
team are trying to do here is actually

1510
00:53:02,290 --> 00:52:59,400
use photo acoustic measurements of a

1511
00:53:04,850 --> 00:53:02,300
particular type of marine bacterium

1512
00:53:06,650 --> 00:53:04,860
cyanobacterium that uses chlorophyll d

1513
00:53:08,270 --> 00:53:06,660

rather than chlorophyll a preferentially

1514
00:53:09,860 --> 00:53:08,280
because it hangs out on the underside of

1515
00:53:12,230 --> 00:53:09,870
this particular creature which I'm not

1516
00:53:13,280 --> 00:53:12,240
even sure what it is but it lives under

1517
00:53:15,260 --> 00:53:13,290
there and it tends to only

1518
00:53:16,880 --> 00:53:15,270
get sort of long-wavelength I read

1519
00:53:19,400 --> 00:53:16,890
infrared radiation in that environment

1520
00:53:21,200 --> 00:53:19,410
and so looking at the efficiency of that

1521
00:53:22,820 --> 00:53:21,210
will help us understand if there really

1522
00:53:25,100 --> 00:53:22,830
is a hard limit for water splitting

1523
00:53:26,750 --> 00:53:25,110
photosynthesis where that might be and

1524
00:53:29,000 --> 00:53:26,760
what the relevance would be for planets

1525
00:53:30,710 --> 00:53:29,010
around stars that have long wavelength

1526
00:53:33,320 --> 00:53:30,720
radiation that comes in like m dwarf

1527
00:53:34,700 --> 00:53:33,330
planets and also on haze covered planets

1528
00:53:36,920 --> 00:53:34,710
like the early Earth where you may be

1529
00:53:38,270 --> 00:53:36,930
blocking a lot of visible radiation but

1530
00:53:39,740 --> 00:53:38,280
allowing radiation through in the

1531
00:53:42,440 --> 00:53:39,750
near-infrared which is the sort of thing

1532
00:53:45,110 --> 00:53:42,450
we see on Titan and Venus any planet

1533
00:53:47,930 --> 00:53:45,120
with a very dense photochemical haze has

1534
00:53:49,700 --> 00:53:47,940
that characteristic we're also working

1535
00:53:50,870 --> 00:53:49,710
on biosphere models we have a bunch of

1536
00:53:53,210 --> 00:53:50,880
them up and running now which is

1537
00:53:55,280 --> 00:53:53,220
fantastic several of them are now

1538
00:53:57,170 --> 00:53:55,290

coupled to GCMs as well so we're

1539
00:53:59,840 --> 00:53:57,180
starting to have the capability to plant

1540
00:54:02,000 --> 00:53:59,850
at play around with alien vegetation and

1541
00:54:05,450 --> 00:54:02,010
its interaction with a more earth-like

1542
00:54:07,520 --> 00:54:05,460
environment we also have recently

1543
00:54:09,830 --> 00:54:07,530
completed the Eve equilibrium

1544
00:54:12,110 --> 00:54:09,840
equilibrium vegetation ecology model

1545
00:54:13,880 --> 00:54:12,120
which is developed by John virgin

1546
00:54:15,440 --> 00:54:13,890
granite counter and yoo-kyung is going

1547
00:54:17,420 --> 00:54:15,450
to be using it with the student to

1548
00:54:19,580 --> 00:54:17,430
actually explore what happens to the

1549
00:54:20,690 --> 00:54:19,590
earth over the next century and in fact

1550
00:54:22,220 --> 00:54:20,700
I think I think they've written up a

1551
00:54:23,540 --> 00:54:22,230
large fraction of that already but

1552
00:54:25,820 --> 00:54:23,550
there's still some work to be done in

1553
00:54:27,350 --> 00:54:25,830
coupling a full a fully interactive

1554
00:54:30,140 --> 00:54:27,360
biosphere into that model having the

1555
00:54:32,540 --> 00:54:30,150
biosphere not just react to climate but

1556
00:54:37,040 --> 00:54:32,550
to react back at the climate and affect

1557
00:54:39,740 --> 00:54:37,050
the climate itself and finally on these

1558
00:54:41,870 --> 00:54:39,750
tasks we have also active fieldwork at

1559
00:54:43,760 --> 00:54:41,880
various sites as I mentioned this is

1560
00:54:45,680 --> 00:54:43,770
Janet C Fritz work at Quatro Cienega s'

1561
00:54:48,470 --> 00:54:45,690
where we are looking at freshwater

1562
00:54:50,750 --> 00:54:48,480
stromatolites in the sort of isolated

1563
00:54:53,000 --> 00:54:50,760

poses in the Mexican desert very

1564
00:54:54,710 --> 00:54:53,010
phosphorous deficient environment and

1565
00:54:56,740 --> 00:54:54,720
again this is work which I think Ariel

1566
00:54:58,880 --> 00:54:56,750
may have already talked about with ASU

1567
00:55:00,890 --> 00:54:58,890
Janet works there specifically on

1568
00:55:02,570 --> 00:55:00,900
horizontal gene transfer but we're also

1569
00:55:04,220 --> 00:55:02,580
very much interested in looking at the

1570
00:55:05,960 --> 00:55:04,230
gases that come off these types of life

1571
00:55:07,730 --> 00:55:05,970
forms and again trying to understand how

1572
00:55:11,150 --> 00:55:07,740
that might feed into a potential bio

1573
00:55:12,830 --> 00:55:11,160
signature okay so finally task E the

1574
00:55:15,110 --> 00:55:12,840
observer I'll just go through this very

1575
00:55:16,790 --> 00:55:15,120
quickly in the observer what we're doing

1576
00:55:18,980 --> 00:55:16,800
is taking the output from all our

1577
00:55:20,480 --> 00:55:18,990
previous simulations and trying to

1578
00:55:21,650 --> 00:55:20,490
understand again what a telescope might

1579
00:55:24,170 --> 00:55:21,660
see and what a telescope should

1580
00:55:26,030 --> 00:55:24,180
potentially look for in addition in this

1581
00:55:26,490 --> 00:55:26,040
task we actually take observations of

1582
00:55:27,690 --> 00:55:26,500
planets

1583
00:55:31,110 --> 00:55:27,700
that's part of our observational

1584
00:55:32,760 --> 00:55:31,120
component astronomy fieldwork and Carl

1585
00:55:33,540 --> 00:55:32,770
Grill Myers on our team - he's the

1586
00:55:35,190 --> 00:55:33,550
person who got the highest

1587
00:55:37,560 --> 00:55:35,200
signal-to-noise spectrum an actual

1588
00:55:39,960 --> 00:55:37,570

spectrum of a Jovian extrasolar planet

1589
00:55:42,120 --> 00:55:39,970
and he was able in that spectrum to see

1590
00:55:43,830 --> 00:55:42,130
a very characteristic signature from the

1591
00:55:46,770 --> 00:55:43,840
shape of the water band which is this

1592
00:55:49,170 --> 00:55:46,780
this dip here and bump here which I'm

1593
00:55:50,490 --> 00:55:49,180
showing that's sort of only the sort of

1594
00:55:51,960 --> 00:55:50,500
thing of spectroscopy could love but

1595
00:55:54,270 --> 00:55:51,970
believe me that's incredibly exciting

1596
00:55:56,250 --> 00:55:54,280
this isn't inferring water just from

1597
00:55:57,840 --> 00:55:56,260
some photometric band that dropped down

1598
00:56:00,210 --> 00:55:57,850
but actually seeing the shape of the

1599
00:56:02,370 --> 00:56:00,220
band in the spectrum of the planet so we

1600
00:56:05,700 --> 00:56:02,380
are making big steps forward in that so

1601
00:56:07,560 --> 00:56:05,710
finally wrapping up our EPO project led

1602
00:56:09,990 --> 00:56:07,570
by Michael Green but with buy-in from a

1603
00:56:12,000 --> 00:56:10,000
lot of our scientists on EPO we have

1604
00:56:14,460 --> 00:56:12,010
five major tasks we're going to

1605
00:56:16,320 --> 00:56:14,470
implement astrobiology distance learning

1606
00:56:18,540 --> 00:56:16,330
courses for in-service and pre-service

1607
00:56:20,010 --> 00:56:18,550
educators not going to get to that this

1608
00:56:21,750 --> 00:56:20,020
year I don't think but we will be

1609
00:56:22,740 --> 00:56:21,760
getting to that next year we're

1610
00:56:24,510 --> 00:56:22,750
interested in entering into a

1611
00:56:26,520 --> 00:56:24,520
partnership to develop an astrobiology

1612
00:56:28,140 --> 00:56:26,530
planetarium show where we use the night

1613
00:56:30,240 --> 00:56:28,150

sky as the context for astrobiological

1614
00:56:32,040 --> 00:56:30,250
questions in astrobiology for education

1615
00:56:34,380 --> 00:56:32,050
we're always interested in collaborating

1616
00:56:35,550 --> 00:56:34,390
with anybody on that one what we're

1617
00:56:36,960 --> 00:56:35,560
doing this year are the last three

1618
00:56:38,910 --> 00:56:36,970
objectives where we're creating an

1619
00:56:40,410 --> 00:56:38,920
outreach toolkit on astrobiology for the

1620
00:56:41,970 --> 00:56:40,420
NASA night sky Network which is a

1621
00:56:44,100 --> 00:56:41,980
network of amateurs right across the

1622
00:56:45,540 --> 00:56:44,110
country who use them amongst themselves

1623
00:56:47,700 --> 00:56:45,550
and also use them to go out and educate

1624
00:56:49,680 --> 00:56:47,710
the public as well with star parties and

1625
00:56:51,780 --> 00:56:49,690
things like that we're launching public

1626
00:56:53,580 --> 00:56:51,790
symposia series we have Frank Drake and

1627
00:56:56,910 --> 00:56:53,590
Debra Fischer coming to talk on

1628
00:57:00,210 --> 00:56:56,920
exoplanets and Howard ability at v-dub

1629
00:57:02,220 --> 00:57:00,220
this this quarter and we'll keep keep

1630
00:57:03,780 --> 00:57:02,230
doing that we're also developing web

1631
00:57:06,240 --> 00:57:03,790
resources in partnership with JPL's

1632
00:57:07,730 --> 00:57:06,250
planet quest site and planet Quest is

1633
00:57:09,720 --> 00:57:07,740
considered to be one of the better

1634
00:57:12,180 --> 00:57:09,730
extrasolar planet in fact the best

1635
00:57:13,950 --> 00:57:12,190
extrasolar planet site so we'll be

1636
00:57:16,590 --> 00:57:13,960
looking at interactive educational

1637
00:57:17,970 --> 00:57:16,600
modules for that just very quickly the

1638
00:57:19,740 --> 00:57:17,980

night sky network as you can see is

1639
00:57:21,990 --> 00:57:19,750
pretty widely distributed and again if

1640
00:57:24,690 --> 00:57:22,000
it's amateur astronomy clubs that then

1641
00:57:26,160 --> 00:57:24,700
go out and educate the public and the

1642
00:57:27,930 --> 00:57:26,170
planet quest the world's number one

1643
00:57:30,030 --> 00:57:27,940
exoplanets website according to Yahoo

1644
00:57:32,550 --> 00:57:30,040
again working in collaboration with

1645
00:57:35,130 --> 00:57:32,560
Michael green at JPL and the planet

1646
00:57:36,540 --> 00:57:35,140
quest website which of at JPL working on

1647
00:57:38,550 --> 00:57:36,550
a bunch of different Interactive's we

1648
00:57:40,170 --> 00:57:38,560
have some ideas for this including ones

1649
00:57:42,000 --> 00:57:40,180
that are virtual tours of Europe

1650
00:57:44,789 --> 00:57:42,010
so we probably need to collaborate with

1651
00:57:48,510 --> 00:57:44,799
our icy moons folks on getting that set

1652
00:57:50,010 --> 00:57:48,520
up and that is pretty much it so if you

1653
00:58:01,490 --> 00:57:50,020
feel in a nutshell science approach

1654
00:58:08,579 --> 00:58:05,130
okay we'll open this up for questions in

1655
00:58:11,789 --> 00:58:08,589
just a moment before we do let me just

1656
00:58:15,230 --> 00:58:11,799
make one brief announcement and then

1657
00:58:18,359 --> 00:58:15,240
make a couple of observations Viki about

1658
00:58:20,279 --> 00:58:18,369
your talk the brief announcement is that

1659
00:58:23,339 --> 00:58:20,289
we have extended the deadline for

1660
00:58:25,680 --> 00:58:23,349
applications to the Santander summer

1661
00:58:28,859 --> 00:58:25,690
school which is a summer school that nai

1662
00:58:30,690 --> 00:58:28,869
and the Centro de espera biología have

1663
00:58:34,319 --> 00:58:30,700

sponsored each year for the last several

1664
00:58:37,049 --> 00:58:34,329
years in Santander Spain the application

1665
00:58:39,539 --> 00:58:37,059
deadline is now April 24th and we

1666
00:58:40,829 --> 00:58:39,549
encourage grad students and postdocs to

1667
00:58:42,960 --> 00:58:40,839
apply the NAI

1668
00:58:45,059 --> 00:58:42,970
provides scholarship so all your

1669
00:58:47,250 --> 00:58:45,069
expenses are paid for and it's a very

1670
00:58:51,299 --> 00:58:47,260
good experience this year it's going to

1671
00:58:54,750 --> 00:58:51,309
be on extremophiles and extraterrestrial

1672
00:58:57,329 --> 00:58:54,760
habitability so related to Vicky's talk

1673
00:59:00,150 --> 00:58:57,339
and I do encourage you to go to the NAI

1674
00:59:02,400 --> 00:59:00,160
website check the latest newsletter

1675
00:59:04,980 --> 00:59:02,410
you'll find the announcement of the

1676
00:59:06,539 --> 00:59:04,990
extension of the deadline and the link

1677
00:59:09,930 --> 00:59:06,549
to the page that gives you the

1678
00:59:12,510 --> 00:59:09,940
application information okay now the

1679
00:59:14,849 --> 00:59:12,520
comment I wanted to make Viki is that of

1680
00:59:16,289 --> 00:59:14,859
course these talks are in part aimed at

1681
00:59:17,579 --> 00:59:16,299
developing connections across the

1682
00:59:19,190 --> 00:59:17,589
Institute and I just wanted to mention

1683
00:59:22,589 --> 00:59:19,200
three connections that occurred to me

1684
00:59:24,809 --> 00:59:22,599
you your team has been extremely good in

1685
00:59:26,309 --> 00:59:24,819
making connections there are three

1686
00:59:29,670 --> 00:59:26,319
possibly new connections

1687
00:59:32,849 --> 00:59:29,680
one is to Melissa trainers work she just

1688
00:59:35,160 --> 00:59:32,859

gave a seminar at u-dub last week so I'm

1689
00:59:37,230 --> 00:59:35,170
sure you've picked up on that but your

1690
00:59:40,799 --> 00:59:37,240
team has a lot of the theoretical

1691
00:59:42,000 --> 00:59:40,809
capability to help understand what's

1692
00:59:43,650 --> 00:59:42,010
actually going on in Melissa's

1693
00:59:46,289 --> 00:59:43,660
experiment so I think that would be a

1694
00:59:50,069 --> 00:59:46,299
really good connection to make another

1695
00:59:52,470 --> 00:59:50,079
is to the work of a postdoc that we just

1696
00:59:56,070 --> 00:59:52,480
announced this election in the NASA

1697
00:59:58,080 --> 00:59:56,080
postdoctoral fellow program in our nai

1698
00:59:59,849 --> 00:59:58,090
component of it and that Stella Kafka

1699
01:00:04,290 --> 00:59:59,859
who's working with Alicia Weinberger at

1700
01:00:07,320 --> 01:00:04,300
Carnegie and she is also working on the

1701
01:00:09,630 --> 01:00:07,330
M star flare problem and is interested

1702
01:00:11,340 --> 01:00:09,640
in looking at the correspondence between

1703
01:00:14,430 --> 01:00:11,350
the astrophysics and the planetary

1704
01:00:16,470 --> 01:00:14,440
habitability and so I'd encourage some

1705
01:00:19,500 --> 01:00:16,480
connections to be made there and the

1706
01:00:21,480 --> 01:00:19,510
final thing is that we've been looking

1707
01:00:24,420 --> 01:00:21,490
with a bunch of folks including Ariel

1708
01:00:28,430 --> 01:00:24,430
and Roger and Doug Irwin and and Peter

1709
01:00:30,750 --> 01:00:28,440
Ward as you probably know at the

1710
01:00:33,750 --> 01:00:30,760
biogeochemical response of Earth's

1711
01:00:35,220 --> 01:00:33,760
biosphere to environmental change and

1712
01:00:38,520 --> 01:00:35,230
some of the things you mentioned at the

1713
01:00:40,410 --> 01:00:38,530

end yuk Yuen and the others doing that

1714
01:00:42,330 --> 01:00:40,420
modeling that you talked about right

1715
01:00:44,849 --> 01:00:42,340
near the end of your talk it's certainly

1716
01:00:46,349 --> 01:00:44,859
very germane to that and Peter can fill

1717
01:00:48,450 --> 01:00:46,359
you in more on a lot of stuff that's

1718
01:00:50,190 --> 01:00:48,460
been going on the last few days so I

1719
01:00:52,320 --> 01:00:50,200
think there's another very valuable

1720
01:00:53,970 --> 01:00:52,330
connection so I'll let you respond and

1721
01:00:55,890 --> 01:00:53,980
in the meanwhile it's open to questions

1722
01:01:00,180 --> 01:00:55,900
just raise your hand and Adobe Connect

1723
01:01:09,030 --> 01:01:00,190
and we'll have a chance to interact more

1724
01:01:10,740 --> 01:01:09,040
with 50 can I respond sorry so yes so

1725
01:01:13,620 --> 01:01:10,750
thank you for all of those suggestions

1726
01:01:16,530 --> 01:01:13,630
yes um yeah Melissa's invitation was no

1727
01:01:18,330 --> 01:01:16,540
coincidence and to come up here so yes

1728
01:01:19,560 --> 01:01:18,340
we are very very interested and we

1729
01:01:21,330 --> 01:01:19,570
actually talked to there after the talk

1730
01:01:22,920 --> 01:01:21,340
about chemical models that could

1731
01:01:24,480 --> 01:01:22,930
potentially help her understand the

1732
01:01:26,130 --> 01:01:24,490
chain of reactions that that was going

1733
01:01:28,080 --> 01:01:26,140
on but of course we also want a better

1734
01:01:29,609 --> 01:01:28,090
characterize our Hayes's for the methane

1735
01:01:31,050 --> 01:01:29,619
modeling so there's a great synergy

1736
01:01:33,359 --> 01:01:31,060
there and yes we will continue to

1737
01:01:35,940 --> 01:01:33,369
interact it Melissa I didn't know about

1738
01:01:39,090 --> 01:01:35,950

Alicia's postdoc but that's fantastic so

1739
01:01:41,910 --> 01:01:39,100
yeah we're very we do have a very much

1740
01:01:43,620 --> 01:01:41,920
MSTAR kind of centric interest at the

1741
01:01:46,020 --> 01:01:43,630
moment and so we very much like to

1742
01:01:48,120 --> 01:01:46,030
interact with that with that postdoc and

1743
01:01:49,800 --> 01:01:48,130
see if we can help out with anything or

1744
01:01:52,349 --> 01:01:49,810
let you know the pitfalls of what we

1745
01:01:54,780 --> 01:01:52,359
tried to do I'm sorry I can't oh the

1746
01:01:57,270 --> 01:01:54,790
third one was the the interaction on

1747
01:02:00,060 --> 01:01:57,280
life's future habitability of climate is

1748
01:02:00,870 --> 01:02:00,070
that correct yeah Peter intimated in an

1749
01:02:01,980 --> 01:02:00,880
email that was something very

1750
01:02:03,089 --> 01:02:01,990
interesting he wanted to talk to me

1751
01:02:04,979 --> 01:02:03,099
about but I didn't get any do

1752
01:02:06,630 --> 01:02:04,989
I'm guessing that's it so when he gets

1753
01:02:08,130 --> 01:02:06,640
back in town I will I will talk to him

1754
01:02:15,689 --> 01:02:08,140
so thank you very much for all of those

1755
01:02:19,349 --> 01:02:15,699
suggestions okay Penn State had a

1756
01:02:21,900 --> 01:02:19,359
question yeah Becky McCauley here from

1757
01:02:24,870 --> 01:02:21,910
Penn State I was curious about what

1758
01:02:26,339 --> 01:02:24,880
fraction of a extrasolar planets orbit

1759
01:02:28,170 --> 01:02:26,349
you'd actually be able to look at and

1760
01:02:33,479 --> 01:02:28,180
like what that means for your temporal

1761
01:02:35,249 --> 01:02:33,489
analysis of the spectra the well again

1762
01:02:37,890 --> 01:02:35,259
that of course that depends on your on

1763
01:02:39,959 --> 01:02:37,900

your telescope overall but the general

1764
01:02:42,029 --> 01:02:39,969
feeling is that once we actually so I'm

1765
01:02:45,239 --> 01:02:42,039
saying for example for TPF which we're I

1766
01:02:48,180 --> 01:02:45,249
know we've looked at the the actual

1767
01:02:49,469 --> 01:02:48,190
detect ability as a function of phase if

1768
01:02:51,449 --> 01:02:49,479
we have one of these things we are going

1769
01:02:52,680 --> 01:02:51,459
to hammer it to death so that that's you

1770
01:02:54,779 --> 01:02:52,690
know a given that we'll spend as much

1771
01:02:56,400 --> 01:02:54,789
time as possible on it but yes we are

1772
01:02:59,969 --> 01:02:56,410
limited really to something between

1773
01:03:01,680 --> 01:02:59,979
dichotomy and the gibbous phase there

1774
01:03:05,370 --> 01:03:01,690
are limits to how close to the star we

1775
01:03:07,259 --> 01:03:05,380
can go so we do have limits on for

1776
01:03:08,609 --> 01:03:07,269
example on a purely edge on orbit how

1777
01:03:10,499 --> 01:03:08,619
much of that orbit we can potentially

1778
01:03:12,809 --> 01:03:10,509
see before we're too close to the star

1779
01:03:14,459 --> 01:03:12,819
either behind it or in front of it with

1780
01:03:16,920 --> 01:03:14,469
orbits that are tilted we do get a

1781
01:03:19,249 --> 01:03:16,930
little bit more of the phase that we can

1782
01:03:21,660 --> 01:03:19,259
look at but overall yes there are

1783
01:03:23,370 --> 01:03:21,670
limitations and that's part of what we'd

1784
01:03:24,630 --> 01:03:23,380
like to simulate as well to say that

1785
01:03:26,489 --> 01:03:24,640
look if you really only got three good

1786
01:03:27,839 --> 01:03:26,499
months what could you do with that you

1787
01:03:36,850 --> 01:03:27,849
know versus being able to track it

1788
01:03:42,640 --> 01:03:39,830

does anybody else have a question for

1789
01:03:48,290 --> 01:03:44,990
my name is prashanta from Montana State

1790
01:03:50,720 --> 01:03:48,300
University my question is is in the

1791
01:03:52,940 --> 01:03:50,730
first part of your talk you're talking

1792
01:03:55,220 --> 01:03:52,950
of developing your models which tries to

1793
01:03:57,500 --> 01:03:55,230
you know talk about where is likely to

1794
01:04:01,010 --> 01:03:57,510
be life that you can obtain to keep

1795
01:04:04,070 --> 01:04:01,020
account of not to commit the fallacy of

1796
01:04:06,440 --> 01:04:04,080
you know positive and false positive but

1797
01:04:09,110 --> 01:04:06,450
what about committing false negatives

1798
01:04:12,620 --> 01:04:09,120
that means the model says there is no

1799
01:04:14,480 --> 01:04:12,630
life but there is my actual right well

1800
01:04:15,470 --> 01:04:14,490
and in fact probably false negatives are

1801
01:04:17,840 --> 01:04:15,480
going to be more like even false

1802
01:04:19,640 --> 01:04:17,850
positives I would imagine and in that we

1803
01:04:20,680 --> 01:04:19,650
don't know the full extent of life

1804
01:04:23,480 --> 01:04:20,690
elsewhere

1805
01:04:25,100 --> 01:04:23,490
what you can try to do is build more

1806
01:04:26,300 --> 01:04:25,110
generalized rules like these rules of

1807
01:04:28,430 --> 01:04:26,310
chemical disequilibrium

1808
01:04:30,590 --> 01:04:28,440
where you really are looking for active

1809
01:04:31,910 --> 01:04:30,600
sources and sinks and and that is

1810
01:04:35,030 --> 01:04:31,920
something that is independent of any

1811
01:04:36,500 --> 01:04:35,040
preconceptions you might have about you

1812
01:04:39,230 --> 01:04:36,510
know what life should be doing in that

1813
01:04:40,820 --> 01:04:39,240

environment but if you if you go down

1814
01:04:42,080 --> 01:04:40,830
that route then you really do have to

1815
01:04:43,580 --> 01:04:42,090
have a very well characterized

1816
01:04:46,160 --> 01:04:43,590
environment to be able to pick up this

1817
01:04:48,710 --> 01:04:46,170
chemical disequilibrium signature and

1818
01:04:50,690 --> 01:04:48,720
you also have to be able to rule out the

1819
01:04:53,150 --> 01:04:50,700
possibility that that can be created by

1820
01:04:55,640 --> 01:04:53,160
something other than life like volcanism

1821
01:04:56,840 --> 01:04:55,650
or whatever so I think when we find life

1822
01:04:58,250 --> 01:04:56,850
I mean you've targeted one of the

1823
01:05:00,140 --> 01:04:58,260
problems is that it really is going to

1824
01:05:01,220 --> 01:05:00,150
be a probabilistic measurement we're

1825
01:05:03,170 --> 01:05:01,230
going to say okay we found these

1826
01:05:05,900 --> 01:05:03,180
characteristics we've done everything we

1827
01:05:07,700 --> 01:05:05,910
can to you know to say whether these

1828
01:05:09,680 --> 01:05:07,710
could be created by something else and

1829
01:05:11,630 --> 01:05:09,690
then we'll come to a probability but

1830
01:05:14,000 --> 01:05:11,640
then that doesn't address you know how

1831
01:05:15,350 --> 01:05:14,010
ignorant we might be of what life could

1832
01:05:16,310 --> 01:05:15,360
potentially what different types of life

1833
01:05:18,320 --> 01:05:16,320
could potentially do to the environment

1834
01:05:20,960 --> 01:05:18,330
and so that's your false negative

1835
01:05:22,370 --> 01:05:20,970
problem so I think the best we can do

1836
01:05:24,350 --> 01:05:22,380
now is just try and work with you know

1837
01:05:26,180 --> 01:05:24,360
the available information that we have

1838
01:05:28,520 --> 01:05:26,190

but keep in the back of our mind exactly

1839
01:05:31,220 --> 01:05:28,530
right that we may just miss it we may

1840
01:05:32,600 --> 01:05:31,230
just you know have no concept of what

1841
01:05:35,420 --> 01:05:32,610
that type of life with digital

1842
01:05:38,000 --> 01:05:35,430
environment we can only really look for

1843
01:05:46,420 --> 01:05:38,010
the life we have some clue or some idea

1844
01:05:51,279 --> 01:05:48,839
are there any other questions for Vicki

1845
01:05:52,839 --> 01:05:51,289
I'll give you a moment to think of one

1846
01:05:54,940 --> 01:05:52,849
by mentioning something I should have

1847
01:05:56,799 --> 01:05:54,950
mentioned that is that your colleague at

1848
01:05:59,710 --> 01:05:56,809
u-dub John Barris is one of the

1849
01:06:03,130 --> 01:05:59,720
lecturers at the Santander summer school

1850
01:06:05,109 --> 01:06:03,140
this year as is Mike Madigan who is the

1851
01:06:07,390 --> 01:06:05,119
senior author on the continuation of

1852
01:06:10,390 --> 01:06:07,400
Brock's microbiology which is a great

1853
01:06:11,890 --> 01:06:10,400
book any of you are not by any chance

1854
01:06:12,400 --> 01:06:11,900
familiar with it and then Ricardo

1855
01:06:14,680 --> 01:06:12,410
Emile's

1856
01:06:17,349 --> 01:06:14,690
and David guillotine ski are likely

1857
01:06:19,210 --> 01:06:17,359
going to be the two European lecturers

1858
01:06:24,700 --> 01:06:19,220
so it'll be a great experience third

1859
01:06:28,450 --> 01:06:24,710
week in June Alan boss from Carnegie and

1860
01:06:30,010 --> 01:06:28,460
the question please go ahead Alan Vicki

1861
01:06:31,210 --> 01:06:30,020
I've got a really wacky question for you

1862
01:06:33,069 --> 01:06:31,220
I've been giving a lot of public talks

1863
01:06:35,589 --> 01:06:33,079

lately about what the tea theatre could

1864
01:06:37,750 --> 01:06:35,599
not do and the occasion people people

1865
01:06:39,220 --> 01:06:37,760
people ask me suppose we're talking

1866
01:06:41,079 --> 01:06:39,230
about looking for life which is not

1867
01:06:41,799 --> 01:06:41,089
based on carbon based on silicon or

1868
01:06:43,269 --> 01:06:41,809
something like that have you ever

1869
01:06:45,400 --> 01:06:43,279
thought about what a silicon-based

1870
01:06:50,140 --> 01:06:45,410
life-form might do in terms of what TPF

1871
01:06:51,789 --> 01:06:50,150
could find most likely people think the

1872
01:06:53,589 --> 01:06:51,799
most is a recce answer people think the

1873
01:06:55,779 --> 01:06:53,599
most likely silicon-based life-form is

1874
01:06:57,099 --> 01:06:55,789
probably a robotic race in which case I

1875
01:07:01,299 --> 01:06:57,109
guess we're looking for Dyson spheres

1876
01:07:02,380 --> 01:07:01,309
and technology I think except of course

1877
01:07:03,700 --> 01:07:02,390
by the time they get to that point they

1878
01:07:06,849 --> 01:07:03,710
probably don't need a Dyson Sphere I

1879
01:07:08,589 --> 01:07:06,859
think you know from arguments with with

1880
01:07:10,089 --> 01:07:08,599
colleagues and chemistry I mean we still

1881
01:07:13,269 --> 01:07:10,099
think that silicon is a far less

1882
01:07:17,200 --> 01:07:13,279
probable basis for life again if Steve

1883
01:07:19,390 --> 01:07:17,210
Banta wants to leave any can but I think

1884
01:07:21,220 --> 01:07:19,400
we still stuck on the carbon-based

1885
01:07:23,950 --> 01:07:21,230
water-based it just really makes more

1886
01:07:25,690 --> 01:07:23,960
chemical sense than silicon overall but

1887
01:07:27,819 --> 01:07:25,700
again the the argument is that

1888
01:07:29,380 --> 01:07:27,829

eventually our organic race may evolve

1889
01:07:31,660 --> 01:07:29,390
to be silicon based we will replace

1890
01:07:34,690 --> 01:07:31,670
ourselves with electronic components and

1891
01:07:36,069 --> 01:07:34,700
therefore we will be you know less our

1892
01:07:38,769 --> 01:07:36,079
habitable zone willing increase

1893
01:07:40,390 --> 01:07:38,779
potentially and that is probably the

1894
01:07:43,120 --> 01:07:40,400
type of silicon-based life we're most

1895
01:07:45,069 --> 01:07:43,130
likely didn't meet the real basic

1896
01:07:45,880 --> 01:07:45,079
question is I suppose if to the extent

1897
01:07:47,559 --> 01:07:45,890
that people have considered

1898
01:07:51,029 --> 01:07:47,569
silicon-based life at all what would be

1899
01:07:52,960 --> 01:07:51,039
the the byproducts of silicon based

1900
01:07:56,710 --> 01:07:52,970
metabolism what would you end up with

1901
01:07:58,660 --> 01:07:56,720
silicon dioxide or would it be I have no

1902
01:08:00,010 --> 01:07:58,670
idea Alan Oh an acid I honestly

1903
01:08:02,920 --> 01:08:00,020
no idea what's going to come out of the

1904
01:08:05,200 --> 01:08:02,930
the reactions Allen take a look at the

1905
01:08:07,990 --> 01:08:05,210
the so-called weird life report the

1906
01:08:10,210 --> 01:08:08,000
limits of life and organic systems that

1907
01:08:13,270 --> 01:08:10,220
the NRC put out a couple of years ago

1908
01:08:15,670 --> 01:08:13,280
and again John Barris with the the

1909
01:08:17,800 --> 01:08:15,680
chairman of that group basically what

1910
01:08:20,020 --> 01:08:17,810
they argue is that you're not going to

1911
01:08:22,090 --> 01:08:20,030
get silicon-based life in water simply

1912
01:08:24,520 --> 01:08:22,100
because the silicon molecules aren't

1913
01:08:26,230 --> 01:08:24,530

stable in water however you could get

1914
01:08:29,170 --> 01:08:26,240
silicon-based life if you were looking

1915
01:08:33,100 --> 01:08:29,180
at a different solvent and so to the

1916
01:08:35,320 --> 01:08:33,110
degree that Vickie is focused on planets

1917
01:08:37,330 --> 01:08:35,330
that contain water silicon-based life

1918
01:08:39,700 --> 01:08:37,340
probably isn't all that much of an issue

1919
01:08:41,620 --> 01:08:39,710
but if you start looking at more diverse

1920
01:08:43,930 --> 01:08:41,630
planets where you have form emit or

1921
01:08:46,300 --> 01:08:43,940
something else i forget which solvents

1922
01:08:49,930 --> 01:08:46,310
they suggest it could support silicon

1923
01:08:53,020 --> 01:08:49,940
based chemistry then you start getting

1924
01:08:54,730 --> 01:08:53,030
into you know sort of the the more

1925
01:08:57,640 --> 01:08:54,740
scientific speculation about your

1926
01:09:01,450 --> 01:08:57,650
question thanks for taking more

1927
01:09:02,560 --> 01:09:01,460
seriously than deserve to be taken yeah

1928
01:09:03,630 --> 01:09:02,570
I was going to say if John was here I'm

1929
01:09:06,280 --> 01:09:03,640
sure he could give you a better answer

1930
01:09:08,050 --> 01:09:06,290
well you know the folks who did the

1931
01:09:10,600 --> 01:09:08,060
weird life report actually took it that

1932
01:09:15,340 --> 01:09:10,610
seriously so we might as well piggyback

1933
01:09:19,330 --> 01:09:15,350
on their enthusiasm for that so are

1934
01:09:34,270 --> 01:09:19,340
there any other questions for Vicki went

1935
01:09:36,220 --> 01:09:34,280
Leigh how Goddard I was doing you went

1936
01:09:37,780 --> 01:09:36,230
through much of it very rapidly but I

1937
01:09:40,140 --> 01:09:37,790
came away with the overall impression

1938
01:09:43,510 --> 01:09:40,150

that you have hundreds of people

1939
01:09:46,630 --> 01:09:43,520
involved in these very insensitive

1940
01:09:50,770 --> 01:09:46,640
hundreds and I can't imagine how you can

1941
01:09:53,170 --> 01:09:50,780
keep all this straight frankly I thought

1942
01:09:55,660 --> 01:09:53,180
my team was big but yours is phenomenal

1943
01:10:00,370 --> 01:09:55,670
but can you just give us the secrets

1944
01:10:08,800 --> 01:10:00,380
that you have Jim casting in line we see

1945
01:10:11,720 --> 01:10:08,810
you there in the Penn State well it is a

1946
01:10:14,600 --> 01:10:11,730
very large team but you know yeah I do

1947
01:10:15,890 --> 01:10:14,610
I do have to keep you know tabs on a lot

1948
01:10:16,850 --> 01:10:15,900
of different people and in fact it was

1949
01:10:18,590 --> 01:10:16,860
quite stressful putting this

1950
01:10:20,900 --> 01:10:18,600
presentation together just trying to

1951
01:10:22,100 --> 01:10:20,910
draw everything in and try and coalesce

1952
01:10:24,860 --> 01:10:22,110
into something that would fit within an

1953
01:10:26,990 --> 01:10:24,870
hour but we we have regular team

1954
01:10:29,570 --> 01:10:27,000
meetings you know at once every two

1955
01:10:32,150 --> 01:10:29,580
weeks or so we have an email exploder

1956
01:10:33,770 --> 01:10:32,160
where a lot of people interact and we of

1957
01:10:35,600 --> 01:10:33,780
course have secondary relationships

1958
01:10:37,400 --> 01:10:35,610
where people are members of the team but

1959
01:10:39,680 --> 01:10:37,410
they collaborate with another task lead

1960
01:10:43,670 --> 01:10:39,690
and so you know I don't necessarily have

1961
01:10:45,770 --> 01:10:43,680
to keep track of everybody but yeah I

1962
01:10:46,880 --> 01:10:45,780
just we just get people involved in this

1963
01:10:49,190 --> 01:10:46,890

I have to say I also have some

1964
01:10:50,660 --> 01:10:49,200
spectacular a productive post Docs so it

1965
01:10:54,080 --> 01:10:50,670
looks like the work of 10 people but it

1966
01:10:56,450 --> 01:10:54,090
sounds in the work of one and and so you

1967
01:10:57,950 --> 01:10:56,460
know I really I really can't give this

1968
01:10:59,600 --> 01:10:57,960
an answer other than the fact that we do

1969
01:11:02,390 --> 01:10:59,610
hang together very well as a team we

1970
01:11:04,130 --> 01:11:02,400
have a lot of interactions and so I do

1971
01:11:06,920 --> 01:11:04,140
get to keep abreast of what people are

1972
01:11:08,780 --> 01:11:06,930
doing on a fairly regular basis and

1973
01:11:13,310 --> 01:11:08,790
keeping Jim casting in line is really

1974
01:11:14,540 --> 01:11:13,320
not a problem at all right Jim is about

1975
01:11:16,100 --> 01:11:14,550
to leap in here because he has the next

1976
01:11:17,420 --> 01:11:16,110
question but now we've had it we've had

1977
01:11:18,890 --> 01:11:17,430
a fabulous relationship with Penn State

1978
01:11:21,110 --> 01:11:18,900
and that's that's part of what helps

1979
01:11:22,580 --> 01:11:21,120
keep us together to Jim and his postdocs

1980
01:11:24,260 --> 01:11:22,590
and grads are what you're seeing

1981
01:11:26,870 --> 01:11:24,270
producing a lot of this stuff here as

1982
01:11:32,270 --> 01:11:26,880
well so very productive collaborators

1983
01:11:35,540 --> 01:11:32,280
and very you know integrated team go

1984
01:11:37,250 --> 01:11:35,550
ahead Jim thanks Vickie actually I think

1985
01:11:39,500 --> 01:11:37,260
what keeps many of us coming back is

1986
01:11:41,930 --> 01:11:39,510
that the cabin any kind of question

1987
01:11:43,970 --> 01:11:41,940
related to exoplanets in life detection

1988
01:11:47,690 --> 01:11:43,980

you can usually get it answered on the

1989
01:11:51,350 --> 01:11:47,700
VP a VP L email responder expander

1990
01:11:52,960 --> 01:11:51,360
within about the three hours or less but

1991
01:11:56,930 --> 01:11:52,970
one comment that I did want to make

1992
01:11:59,900 --> 01:11:56,940
Vicky was in respect to this question of

1993
01:12:02,300 --> 01:11:59,910
alien life and bio signatures life may

1994
01:12:04,850 --> 01:12:02,310
be very alien but thermodynamics is

1995
01:12:06,590 --> 01:12:04,860
universal and so you know I agree with

1996
01:12:08,930 --> 01:12:06,600
Carl I thought you gave a good answer to

1997
01:12:10,550 --> 01:12:08,940
the silicon life question but if you

1998
01:12:13,640 --> 01:12:10,560
have carbon-based life this may be

1999
01:12:15,950 --> 01:12:13,650
totally different from you know ours not

2000
01:12:17,540 --> 01:12:15,960
DNA or RNA but something different I

2001
01:12:19,340 --> 01:12:17,550
think you're still going to end up with

2002
01:12:21,530 --> 01:12:19,350
the same types of byproducts of

2003
01:12:23,270 --> 01:12:21,540
metabolism that you get here on earth

2004
01:12:24,089 --> 01:12:23,280
just because certain things are

2005
01:12:26,459 --> 01:12:24,099
thermodynamic

2006
01:12:29,159 --> 01:12:26,469
favored and organisms can make a living

2007
01:12:37,080 --> 01:12:29,169
so there is you know some more general

2008
01:12:39,689 --> 01:12:37,090
justification to that right I agree one

2009
01:12:42,359 --> 01:12:39,699
of the things I'd mention in response to

2010
01:12:44,699 --> 01:12:42,369
Mike's observation is that Vicki uses

2011
01:12:48,540 --> 01:12:44,709
the technology that we are using right

2012
01:12:50,219 --> 01:12:48,550
now namely the ability to use the

2013
01:12:52,770 --> 01:12:50,229

multi-point control unit that's

2014
01:12:54,299 --> 01:12:52,780
providing this very nice picture that

2015
01:12:56,369 --> 01:12:54,309
you're all looking at now and seeing

2016
01:12:58,109 --> 01:12:56,379
everybody smiling faces and Adobe

2017
01:13:01,500 --> 01:12:58,119
Connect and all of that so I just

2018
01:13:04,589 --> 01:13:01,510
mentioned that to encourage everybody to

2019
01:13:06,629 --> 01:13:04,599
consider using this in any way as you

2020
01:13:09,659 --> 01:13:06,639
manage your teams in your research it's

2021
01:13:12,869 --> 01:13:09,669
available to all of you we can train

2022
01:13:14,790 --> 01:13:12,879
your IT folks on how to use it but

2023
01:13:16,979 --> 01:13:14,800
basically there's a web interface and

2024
01:13:18,359 --> 01:13:16,989
this technology is available to all of

2025
01:13:20,339 --> 01:13:18,369
you so any of you can be running a

2026
01:13:22,909 --> 01:13:20,349
meeting like this one and I know Vicki

2027
01:13:25,109 --> 01:13:22,919
has been using that as one of her tools

2028
01:13:27,810 --> 01:13:25,119
so are there any other questions for

2029
01:13:31,109 --> 01:13:27,820
Vicki yes I'm a question from Colorado

2030
01:13:33,179 --> 01:13:31,119
okay go ahead Vicki this is Katherine

2031
01:13:35,099 --> 01:13:33,189
right from Colorado you were talking

2032
01:13:37,409 --> 01:13:35,109
about modeling planets with liquid water

2033
01:13:39,119 --> 01:13:37,419
on the surface and I wanted to ask since

2034
01:13:41,040 --> 01:13:39,129
it's quite possible for a planet to be

2035
01:13:42,270 --> 01:13:41,050
habitable without liquid water on the

2036
01:13:43,739 --> 01:13:42,280
surface if there's water underground

2037
01:13:48,199 --> 01:13:43,749
where they're also modeling that type of

2038
01:13:51,119 --> 01:13:48,209

planet um I guess the answer is not yet

2039
01:13:52,560 --> 01:13:51,129
they I mean our concern with liquid

2040
01:13:53,790 --> 01:13:52,570
water on a service and I know this is

2041
01:13:55,819 --> 01:13:53,800
this is a hot-button issue in the

2042
01:13:57,779 --> 01:13:55,829
astrobiology community that this this

2043
01:14:00,750 --> 01:13:57,789
discrimination between surface and

2044
01:14:02,609 --> 01:14:00,760
subsurface life we stick to surface life

2045
01:14:04,830 --> 01:14:02,619
just because it's more detectable over

2046
01:14:07,889 --> 01:14:04,840
very large distances it it is harder

2047
01:14:10,020 --> 01:14:07,899
with subsurface life to detect for

2048
01:14:12,029 --> 01:14:10,030
example any surface features from it the

2049
01:14:15,239 --> 01:14:12,039
gases may get released in and get up

2050
01:14:16,619 --> 01:14:15,249
into the atmosphere and and that may be

2051
01:14:18,389 --> 01:14:16,629
significant our planet with a lot of

2052
01:14:20,729 --> 01:14:18,399
geothermal activity but if you're

2053
01:14:23,580 --> 01:14:20,739
looking at you know photosynthetically

2054
01:14:24,989 --> 01:14:23,590
driven liquid water life then you really

2055
01:14:26,369 --> 01:14:24,999
need to be on the surface obviously to

2056
01:14:28,139 --> 01:14:26,379
get the kind of biomass the kind of

2057
01:14:30,299 --> 01:14:28,149
output that we're more likely to detect

2058
01:14:31,889 --> 01:14:30,309
so I think first off the bat when these

2059
01:14:33,689 --> 01:14:31,899
missions are going to be struggling

2060
01:14:35,849 --> 01:14:33,699
definitely to get enough protons from

2061
01:14:37,290 --> 01:14:35,859
these planets that we do tend to have

2062
01:14:39,510 --> 01:14:37,300
this bias that we want the

2063
01:14:41,490 --> 01:14:39,520

to be on the surface just because it's

2064
01:14:43,170 --> 01:14:41,500
easier to detect it's more likely to

2065
01:14:45,320 --> 01:14:43,180
eventually gotten photosynthesis and so

2066
01:14:47,850 --> 01:14:45,330
be a highly productive biosphere as well

2067
01:14:51,570 --> 01:14:47,860
so that's kind of our bias at the moment

2068
01:14:52,920 --> 01:14:51,580
but you know if if it's possible that

2069
01:14:55,230 --> 01:14:52,930
subsurface life can release enough

2070
01:14:56,700 --> 01:14:55,240
things is inefficient enough that it

2071
01:14:59,280 --> 01:14:56,710
releases enough stuff into the

2072
01:15:01,530 --> 01:14:59,290
atmosphere I mean most most areas where

2073
01:15:03,450 --> 01:15:01,540
resources are limited if you tend to get

2074
01:15:05,190 --> 01:15:03,460
its efficiency where you know in a

2075
01:15:06,660 --> 01:15:05,200
microbial mat you don't let anything out

2076
01:15:08,760 --> 01:15:06,670
the top if you can possibly avoid it you

2077
01:15:10,890 --> 01:15:08,770
know somebody usually involves to use it

2078
01:15:12,450 --> 01:15:10,900
so in that case this would have to be

2079
01:15:15,270 --> 01:15:12,460
sort of a release from the biosphere

2080
01:15:16,830 --> 01:15:15,280
into the service environment and we just

2081
01:15:18,930 --> 01:15:16,840
think that maybe that's less likely or

2082
01:15:28,640 --> 01:15:18,940
more difficult to see but those are our

2083
01:15:34,650 --> 01:15:32,250
okay let me just announce attention that

2084
01:15:37,020 --> 01:15:34,660
the seminar on Wednesday of this week

2085
01:15:39,360 --> 01:15:37,030
will be by Mike Miller for the Goddard

2086
01:15:41,100 --> 01:15:39,370
team same time same Channel

2087
01:15:49,500 --> 01:15:41,110
look forward to seeing you then and