AB GRAD CON23

1
00:00:00,000 --> 00:00:04,220
hello

2
00:00:04,230 --> 00:00:13,430
[Music]

3
00:00:18,710 --> 00:00:15,589
pleasure to be here

4
00:00:20,390 --> 00:00:18,720
uh so I'm in the program in Applied

5
00:00:23,450 --> 00:00:20,400
Mathematics at the University of Arizona

6
00:00:27,529 --> 00:00:23,460
but I work with Professor Regis farrier

7
00:00:30,170 --> 00:00:27,539
who's an ecologist and a postdoc antenna

8
00:00:33,530 --> 00:00:30,180
affolder who is also an ecologist and

9
00:00:36,889 --> 00:00:33,540
planetary scientist so we developed

10
00:00:39,709 --> 00:00:36,899
these Global models of Europa and so

11
00:00:41,270 --> 00:00:39,719
what you see right here is the Europa

12
00:00:43,670 --> 00:00:41,280
Clipper Mission which is going to launch

13
00:00:45,889 --> 00:00:43,680

next year in October hopefully and I

14
00:00:49,250 --> 00:00:45,899
believe it's the largest in terms of

15
00:00:52,190 --> 00:00:49,260
size spacecraft that NASA's ever built

16
00:00:54,049 --> 00:00:52,200
because of those massive solar panels

17
00:00:58,069 --> 00:00:54,059
um because we're when we're five times

18
00:01:00,410 --> 00:00:58,079
away from the Sun at Jupiter I think the

19
00:01:07,250 --> 00:01:00,420
brightness scales like inverse Square

20
00:01:13,070 --> 00:01:09,950
so why do we care about Europa

21
00:01:15,230 --> 00:01:13,080
so beneath the ice crust we have an

22
00:01:17,270 --> 00:01:15,240
ocean which potentially contains two to

23
00:01:20,030 --> 00:01:17,280
three times the amount of water as on

24
00:01:22,429 --> 00:01:20,040
Earth which is when I first discovered

25
00:01:23,810 --> 00:01:22,439
that fact I was just so blown away by

26
00:01:25,910 --> 00:01:23,820
that

27
00:01:29,090 --> 00:01:25,920
um and we have an energy source from

28
00:01:31,310 --> 00:01:29,100
tidal heating uh namely we may have

29
00:01:33,710 --> 00:01:31,320
hydrothermal venting as a result of that

30
00:01:36,230 --> 00:01:33,720
we saw that on Enceladus because we saw

31
00:01:37,910 --> 00:01:36,240
silicates in the plumes we haven't

32
00:01:40,429 --> 00:01:37,920
confirmed that yet in Europa but it's

33
00:01:42,130 --> 00:01:40,439
very likely based on the amount of tidal

34
00:01:46,609 --> 00:01:42,140
energy that we expect

35
00:01:49,789 --> 00:01:46,619
and we also have a rock ocean interface

36
00:01:52,190 --> 00:01:49,799
so that's very essential for you know

37
00:01:55,190 --> 00:01:52,200
cycling chemicals needed for life

38
00:01:57,230 --> 00:01:55,200

uh and we have a lot of convection as

39
00:01:59,450 --> 00:01:57,240
Sarah talked about

40
00:02:02,569 --> 00:01:59,460
um which is very essential also for

41
00:02:07,429 --> 00:02:05,630
so as a result we need these models to

42
00:02:10,130 --> 00:02:07,439
constrain what we're going to see from

43
00:02:12,290 --> 00:02:10,140
the mission so we had juice also the esa

44
00:02:13,190 --> 00:02:12,300
Mission let's not forget about that

45
00:02:15,170 --> 00:02:13,200
um

46
00:02:16,309 --> 00:02:15,180
so we need to model all these different

47
00:02:16,970 --> 00:02:16,319
layers

48
00:02:19,250 --> 00:02:16,980
um

49
00:02:22,250 --> 00:02:19,260
so working off what we did for install

50
00:02:24,290 --> 00:02:22,260
it is to analyze the Cassini data we're

51
00:02:28,790 --> 00:02:24,300
going to do that here specifically

52
00:02:30,229 --> 00:02:28,800
focusing on the ecosystem aspect

53
00:02:32,570 --> 00:02:30,239
um and so what we want to do with that

54
00:02:33,830 --> 00:02:32,580
is provide clear constraints on what

55
00:02:35,750 --> 00:02:33,840
kind of BIOS Industries we're going to

56
00:02:39,949 --> 00:02:35,760
expect based on a number of different

57
00:02:42,770 --> 00:02:39,959
hypotheses uh of abiotic

58
00:02:48,410 --> 00:02:42,780
possibilities biotic possibilities and

59
00:02:53,809 --> 00:02:50,690
so as I said our approach is very

60
00:02:55,910 --> 00:02:53,819
multi-level uh we are going to first

61
00:02:59,390 --> 00:02:55,920
look at the bottom layer which is the

62
00:03:00,949 --> 00:02:59,400
mixing of the core and the ocean to

63
00:03:02,449 --> 00:03:00,959

assess you know the chemical structure

64
00:03:05,270 --> 00:03:02,459
coming out of you know coming out

65
00:03:07,009 --> 00:03:05,280
through through the water passing

66
00:03:08,869 --> 00:03:07,019
through the core

67
00:03:10,670 --> 00:03:08,879
and what chemicals are going to come

68
00:03:12,589 --> 00:03:10,680
through that we're going to have to

69
00:03:15,229 --> 00:03:12,599
assess what how that mixes in the water

70
00:03:17,509 --> 00:03:15,239
to assess how much uh chemicals we're

71
00:03:20,149 --> 00:03:17,519
going to see coming out of the plumes

72
00:03:22,910 --> 00:03:20,159
and then we also need to take some model

73
00:03:25,330 --> 00:03:22,920
organisms from Earth to understand the

74
00:03:28,130 --> 00:03:25,340
metabolisms that we might expect

75
00:03:30,830 --> 00:03:28,140
along with the ecological and possible

76
00:03:33,229 --> 00:03:30,840
evolutionary dynamics of the life that

77
00:03:35,509 --> 00:03:33,239
we're modeling

78
00:03:38,030 --> 00:03:35,519
so with this framework we're going to

79
00:03:40,369 --> 00:03:38,040
estimate the likelihoods of certain data

80
00:03:44,330 --> 00:03:40,379
sets that we're going to see via a

81
00:03:49,190 --> 00:03:46,490
so to intimidate you a little bit we're

82
00:03:51,050 --> 00:03:49,200
going to have some math

83
00:03:53,530 --> 00:03:51,060
um so let's talk about the mixing we

84
00:03:56,210 --> 00:03:53,540
look at the dimensionless mixing ratio X

85
00:03:58,190 --> 00:03:56,220
and the temperature T so we have a

86
00:04:00,470 --> 00:03:58,200
partial differential equation which with

87
00:04:02,149 --> 00:04:00,480
spatial and time variables

88
00:04:04,970 --> 00:04:02,159

solving this partial differential

89
00:04:06,710 --> 00:04:04,980
equation gives us this steady state

90
00:04:09,530 --> 00:04:06,720
composition

91
00:04:12,649 --> 00:04:09,540
and temperature of the mixing layer with

92
00:04:16,550 --> 00:04:12,659
the mass flux density

93
00:04:21,650 --> 00:04:18,949
we can compute what we're going to see

94
00:04:25,310 --> 00:04:21,660
coming out of the plumes by integrating

95
00:04:27,890 --> 00:04:25,320
over the entire space so we we integrate

96
00:04:30,650 --> 00:04:27,900
the integrand contains this Mass flux

97
00:04:32,570 --> 00:04:30,660
density and the concentration of a

98
00:04:35,510 --> 00:04:32,580
specific chemical component that we're

99
00:04:39,530 --> 00:04:35,520
looking at so whether that be a glycine

100
00:04:40,790 --> 00:04:39,540
or other amino acids or you know cells

101
00:04:44,570 --> 00:04:40,800
potentially

102
00:04:47,090 --> 00:04:44,580
so the concentration of this compound at

103
00:04:49,909 --> 00:04:47,100
the base of the ocean plume assuming

104
00:04:51,530 --> 00:04:49,919
that the buoyant mixing layer mixes

105
00:04:53,150 --> 00:04:51,540
together as we described from the

106
00:04:55,850 --> 00:04:53,160
previous model

107
00:04:59,150 --> 00:04:55,860
is given by this quotient of these

108
00:05:03,890 --> 00:05:01,129
so then we want to look at the cell

109
00:05:05,810 --> 00:05:03,900
metabolism and output and there's a very

110
00:05:08,930 --> 00:05:05,820
large variety of possibilities we could

111
00:05:10,790 --> 00:05:08,940
be working with here so we kind of run

112
00:05:14,450 --> 00:05:10,800
the model for tons and tons of

113
00:05:15,890 --> 00:05:14,460

possibilities of Earth analogs

114
00:05:18,770 --> 00:05:15,900
um depending on these environmental

115
00:05:21,830 --> 00:05:18,780
conditions so we model this catabolic

116
00:05:25,189 --> 00:05:21,840
reaction rate of a specific organism

117
00:05:27,110 --> 00:05:25,199
using the Arrhenius law I know that came

118
00:05:29,029 --> 00:05:27,120
up yesterday Arrhenius in one of the

119
00:05:29,770 --> 00:05:29,039
trivia questions

120
00:05:31,790 --> 00:05:29,780
um

121
00:05:33,969 --> 00:05:31,800
uh so

122
00:05:38,390 --> 00:05:33,979
and that's so the Arrhenius law is

123
00:05:40,850 --> 00:05:38,400
specifically this quotient here and we

124
00:05:44,570 --> 00:05:40,860
use the catabolic energy constant for

125
00:05:47,390 --> 00:05:44,580
given by this term and it goes in here

126
00:05:52,430 --> 00:05:47,400
to understand the ratio of inactivated

127
00:05:54,890 --> 00:05:52,440
to activated enzymes for the reaction

128
00:05:57,770 --> 00:05:54,900
now critically we assess the ecological

129
00:06:00,170 --> 00:05:57,780
dynamics of the system so

130
00:06:02,090 --> 00:06:00,180
in this case we are dealing with one

131
00:06:06,529 --> 00:06:02,100
population

132
00:06:11,210 --> 00:06:07,969
ode model

133
00:06:12,610 --> 00:06:11,220
describing the Dynamics but we've been

134
00:06:15,170 --> 00:06:12,620
thinking about incorporating

135
00:06:17,029 --> 00:06:15,180
multi-species into this because there's

136
00:06:18,529 --> 00:06:17,039
actually a significant dynamical

137
00:06:21,890 --> 00:06:18,539
difference when you have competition

138
00:06:23,689 --> 00:06:21,900

between species in the environment and

139
00:06:26,930 --> 00:06:23,699
that would seriously affect what we'll

140
00:06:29,350 --> 00:06:26,940
see when we go there so we have to we

141
00:06:32,150 --> 00:06:29,360
have to have multiple different

142
00:06:33,950 --> 00:06:32,160
ecosystem Dynamics models

143
00:06:37,510 --> 00:06:33,960
and so we solve this and get a steady

144
00:06:41,870 --> 00:06:37,520
state concentration of a specific uh

145
00:06:46,790 --> 00:06:43,909
so what can we learn from specifically

146
00:06:48,290 --> 00:06:46,800
the Europa Clipper Mission so the Europa

147
00:06:50,870 --> 00:06:48,300
Clipper Mission has some very

148
00:06:53,689 --> 00:06:50,880
interesting instruments we have a

149
00:06:55,969 --> 00:06:53,699
mapping Imaging spectrometer so it will

150
00:06:58,309 --> 00:06:55,979
map the surface and conduct the

151
00:07:00,469 --> 00:06:58,319
spectroscopy of the surface and the

152
00:07:02,510 --> 00:07:00,479
distribution of the Organics so as

153
00:07:05,029 --> 00:07:02,520
things come out of the plumes they they

154
00:07:06,890 --> 00:07:05,039
fall onto the surface and we should

155
00:07:08,390 --> 00:07:06,900
expect to see an interesting chemical

156
00:07:11,450 --> 00:07:08,400
composition I know they're already doing

157
00:07:14,090 --> 00:07:11,460
this with jwst from the from a distance

158
00:07:15,770 --> 00:07:14,100
they haven't analyzed that data yet but

159
00:07:19,809 --> 00:07:15,780
uh should be interesting

160
00:07:23,330 --> 00:07:19,819
and then to sort of sniff the exosphere

161
00:07:26,510 --> 00:07:23,340
of Europa we have a mass spectrometer

162
00:07:28,969 --> 00:07:26,520
Mass specs it'll determine the the

163
00:07:31,309 --> 00:07:28,979

composition of the of the ocean beneath

164
00:07:33,529 --> 00:07:31,319
by sniffing that exosphere

165
00:07:36,050 --> 00:07:33,539
and then we have a surface dust analyzer

166
00:07:40,670 --> 00:07:36,060
uh it'll have it'll measure like the

167
00:07:44,350 --> 00:07:43,070
and so in this image you can see kind of

168
00:07:50,870 --> 00:07:44,360
a remote

169
00:07:55,909 --> 00:07:53,330
so let's focus on this slide a little

170
00:07:58,909 --> 00:07:55,919
bit so this is the overall framework so

171
00:08:00,650 --> 00:07:58,919
at the top we have those mechanistic

172
00:08:03,290 --> 00:08:00,660
models for the geochemistry and the

173
00:08:05,570 --> 00:08:03,300
biology that we discussed earlier

174
00:08:09,230 --> 00:08:05,580
and so the flow of information goes from

175
00:08:10,909 --> 00:08:09,240
the top as prior probability probability

176
00:08:14,930 --> 00:08:10,919
densities

177
00:08:16,189 --> 00:08:14,940
that flow into as parameters into the

178
00:08:19,129 --> 00:08:16,199
general model

179
00:08:21,409 --> 00:08:19,139
then we pass those parameters into the

180
00:08:22,969 --> 00:08:21,419
biological model for physiology and

181
00:08:24,950 --> 00:08:22,979
evolution

182
00:08:27,529 --> 00:08:24,960
which then goes to our habitability

183
00:08:30,469 --> 00:08:27,539
Criterion so the habitability Criterion

184
00:08:32,269 --> 00:08:30,479
that we generally use here is it's a

185
00:08:33,889 --> 00:08:32,279
differential equation describing the

186
00:08:36,110 --> 00:08:33,899
population so essentially if I were to

187
00:08:38,329 --> 00:08:36,120
take an Earth-like organism drop it onto

188
00:08:40,130 --> 00:08:38,339

Europa would the change in the

189
00:08:42,170 --> 00:08:40,140
population be positive or would it be

190
00:08:44,269 --> 00:08:42,180
zero so the derivative of population

191
00:08:46,970 --> 00:08:44,279
growth essentially

192
00:08:49,730 --> 00:08:46,980
and so we pass that into Bayes theorem

193
00:08:53,630 --> 00:08:49,740
as prior distributions the posterior

194
00:08:57,769 --> 00:08:53,640
distributions uh come from these uh so

195
00:09:00,590 --> 00:08:57,779
we okay actually to be more specific

196
00:09:02,389 --> 00:09:00,600
we simulate all of these models with

197
00:09:05,090 --> 00:09:02,399
thousands of data points

198
00:09:06,829 --> 00:09:05,100
to get what we call pseudo data in

199
00:09:09,769 --> 00:09:06,839
what's called an approximate Bayesian

200
00:09:12,470 --> 00:09:09,779
computation and so we pass that into the

201
00:09:15,050 --> 00:09:12,480
model and we take the observational data

202
00:09:17,090 --> 00:09:15,060
and we put that into base theorem so if

203
00:09:19,550 --> 00:09:17,100
any of you are aware of Bayes theorem

204
00:09:21,710 --> 00:09:19,560
that is a way of assessing the

205
00:09:23,389 --> 00:09:21,720
probability of a certain event given

206
00:09:25,310 --> 00:09:23,399
prior information and given posterior

207
00:09:27,290 --> 00:09:25,320
information

208
00:09:29,090 --> 00:09:27,300
um and so now we have this cycle of

209
00:09:30,530 --> 00:09:29,100
information so after we get a

210
00:09:32,269 --> 00:09:30,540
probability from base theorem we can

211
00:09:34,130 --> 00:09:32,279
pass it back into the geophysical

212
00:09:36,350 --> 00:09:34,140
parameters model and then continue to

213
00:09:38,410 --> 00:09:36,360

constrain as we get more observational

214
00:09:41,150 --> 00:09:38,420
data

215
00:09:45,050 --> 00:09:41,160
so here's an example of how we did that

216
00:09:47,810 --> 00:09:45,060
with Enceladus for Cassini

217
00:09:50,269 --> 00:09:47,820
so in this graph here you can see the

218
00:09:51,710 --> 00:09:50,279
blue dots are simulations for

219
00:09:53,630 --> 00:09:51,720
uninhabitable

220
00:09:56,110 --> 00:09:53,640
parameter space

221
00:09:59,389 --> 00:09:56,120
the orange dots are

222
00:10:01,970 --> 00:09:59,399
uninhabited but habitable

223
00:10:03,470 --> 00:10:01,980
and the green dots are habitable and

224
00:10:06,110 --> 00:10:03,480
habited

225
00:10:08,090 --> 00:10:06,120
so what you can see uh from analyzing

226
00:10:10,190 --> 00:10:08,100
the methane content of the plume and

227
00:10:13,009 --> 00:10:10,200
Cassini using this framework was that

228
00:10:15,290 --> 00:10:13,019
the vast majority of simulations for all

229
00:10:19,070 --> 00:10:15,300
the possibilities we assessed

230
00:10:20,150 --> 00:10:19,080
fall under the biotic category

231
00:10:24,350 --> 00:10:20,160
um

232
00:10:30,230 --> 00:10:27,889
I mean that speaks for itself right

233
00:10:32,630 --> 00:10:30,240
so um but there's a very important

234
00:10:34,730 --> 00:10:32,640
constraint on this namely the

235
00:10:37,490 --> 00:10:34,740
probability of abiogenesis

236
00:10:39,110 --> 00:10:37,500
so what we do in this model is assess

237
00:10:42,310 --> 00:10:39,120
all the possibilities from probability

238
00:10:45,410 --> 00:10:42,320

zero to probability one of abiogenesis

239
00:10:49,250 --> 00:10:45,420
and so what we found was at a pretty low

240
00:10:52,069 --> 00:10:49,260
probability of abiogenesis uh the from

241
00:10:53,569 --> 00:10:52,079
the previous slide

242
00:10:56,150 --> 00:10:53,579
um

243
00:10:58,490 --> 00:10:56,160
with a low probability of a biogenesis

244
00:11:00,350 --> 00:10:58,500
you see that biotic explanations are the

245
00:11:03,050 --> 00:11:00,360
most probable for what we're seeing the

246
00:11:05,870 --> 00:11:03,060
in the methane content so we really need

247
00:11:08,690 --> 00:11:05,880
to develop our models of abiogenesis to

248
00:11:11,949 --> 00:11:08,700
really limit limit this variable and

249
00:11:16,009 --> 00:11:11,959
constrain this probability

250
00:11:18,769 --> 00:11:16,019
so the conclusion is in order to find

251
00:11:21,050 --> 00:11:18,779
life we really have to model these

252
00:11:22,610 --> 00:11:21,060
planetary systems with the assumption

253
00:11:24,590 --> 00:11:22,620
that there could be life there already

254
00:11:25,970 --> 00:11:24,600
because if we don't we're going to show

255
00:11:28,370 --> 00:11:25,980
up there and we're going to think okay

256
00:11:30,530 --> 00:11:28,380
it's habitable but why because

257
00:11:32,210 --> 00:11:30,540
potentially the habitability of a planet

258
00:11:34,250 --> 00:11:32,220
is actually coming from the life is

259
00:11:36,889 --> 00:11:34,260
already there so we have to incorporate

260
00:11:39,910 --> 00:11:36,899
that into our into our potential models

261
00:11:42,769 --> 00:11:39,920
so this will allow us to really enhance

262
00:11:43,449 --> 00:11:42,779
Mission data analysis

263
00:11:46,490 --> 00:11:43,459

um

264
00:11:48,889 --> 00:11:46,500
beforehand uh so you know with when we

265
00:11:50,630 --> 00:11:48,899
had Cassini we showed up there and we

266
00:11:53,210 --> 00:11:50,640
had no idea what was going on we're like

267
00:11:55,910 --> 00:11:53,220
wild plumes this is amazing

268
00:11:58,190 --> 00:11:55,920
um but it took many many years to really

269
00:12:00,170 --> 00:11:58,200
assess this so hopefully with Europa

270
00:12:03,350 --> 00:12:00,180
Clipper we have this framework in hand

271
00:12:06,650 --> 00:12:03,360
as a software package so the data can be

272
00:12:09,470 --> 00:12:06,660
fed through real time and the benefit of

273
00:12:11,329 --> 00:12:09,480
this is then we can narrow down in on

274
00:12:13,730 --> 00:12:11,339
specific areas of Europa that are of

275
00:12:16,910 --> 00:12:13,740
interest to us and really maximize the

276
00:12:30,170 --> 00:12:16,920
scientific yield of these missions

277
00:12:37,250 --> 00:12:34,009
uh nice talk uh two questions maybe the

278
00:12:38,630 --> 00:12:37,260
first did you choose a prior for a

279
00:12:41,030 --> 00:12:38,640
biogenesis

280
00:12:42,829 --> 00:12:41,040
yeah so we sampled the entire space from

281
00:12:45,230 --> 00:12:42,839
zero to one probability

282
00:12:47,449 --> 00:12:45,240
in that in those 10 000 or so

283
00:12:49,310 --> 00:12:47,459
simulations

284
00:12:51,710 --> 00:12:49,320
so basically

285
00:12:53,750 --> 00:12:51,720
um we can't pick a prior for abiogenesis

286
00:12:56,150 --> 00:12:53,760
there's no constraint on that variable

287
00:12:57,889 --> 00:12:56,160
uh so essentially we have to run the

288
00:13:00,949 --> 00:12:57,899

model for all possibilities of

289
00:13:03,710 --> 00:13:00,959
abiogenesis so so like I said

290
00:13:06,230 --> 00:13:03,720
specifically with the Enceladus data we

291
00:13:08,449 --> 00:13:06,240
found that uh much less than 50 percent

292
00:13:10,490 --> 00:13:08,459
chance abiogenesis ensures that the

293
00:13:12,650 --> 00:13:10,500
biotic explanation is the most probable

294
00:13:16,009 --> 00:13:12,660
explanation I believe is around 30 or

295
00:13:18,829 --> 00:13:16,019
less probability but if you're beneath

296
00:13:21,350 --> 00:13:18,839
that threshold then really the abiotic

297
00:13:24,350 --> 00:13:21,360
explanations are way more probable even

298
00:13:27,050 --> 00:13:24,360
though the samples from the abiotic

299
00:13:28,670 --> 00:13:27,060
simulations are much smaller but you

300
00:13:30,290 --> 00:13:28,680
know when the probability of evangelists

301
00:13:33,110 --> 00:13:30,300
is really low

302
00:13:34,250 --> 00:13:33,120
it's just not going to happen right so

303
00:13:48,110 --> 00:13:34,260
okay yeah that answered my second

304
00:13:53,810 --> 00:13:51,230
hey thank you for your talk so for

305
00:13:55,250 --> 00:13:53,820
Europa are you also in terms of

306
00:13:58,610 --> 00:13:55,260
metabolism are you thinking about

307
00:14:01,009 --> 00:13:58,620
methanogenesis or yeah okay so that was

308
00:14:03,769 --> 00:14:01,019
the first step to consider um infer

309
00:14:05,569 --> 00:14:03,779
Enceladus it was kind of a the most

310
00:14:07,490 --> 00:14:05,579
obvious thing to look at because of the

311
00:14:11,329 --> 00:14:07,500
methane content

312
00:14:13,670 --> 00:14:11,339
um with Europa it's more complex uh

313
00:14:15,769 --> 00:14:13,680

because we don't have any real data from

314
00:14:17,629 --> 00:14:15,779
Europa and also the environments on

315
00:14:19,670 --> 00:14:17,639
Europa are much more varied you have

316
00:14:21,710 --> 00:14:19,680
subsurface pockets of water along with

317
00:14:23,750 --> 00:14:21,720
the ocean and maybe you have like

318
00:14:26,810 --> 00:14:23,760
biofilms on the bottom of the eye so

319
00:14:29,750 --> 00:14:26,820
it's it's a much more complex thing

320
00:14:31,250 --> 00:14:29,760
um so my hope is to uh run all the

321
00:14:34,490 --> 00:14:31,260
simulations for all the possible

322
00:14:36,650 --> 00:14:34,500
hypotheses that exist currently okay and

323
00:14:39,050 --> 00:14:36,660
I have one little follow-up question so

324
00:14:40,310 --> 00:14:39,060
you very briefly talked about Dynamic

325
00:14:42,290 --> 00:14:40,320
communities and you mentioned

326
00:14:44,930 --> 00:14:42,300
competition are you just looking at

327
00:14:47,389 --> 00:14:44,940
competition or are you looking at other

328
00:14:49,189 --> 00:14:47,399
sorts of consortiums like in a biofilm

329
00:14:53,329 --> 00:14:49,199
there's competition but there's also

330
00:14:55,670 --> 00:14:53,339
lots of sharing going on right so um if

331
00:14:57,530 --> 00:14:55,680
we're including multi-species in our

332
00:15:00,170 --> 00:14:57,540
models we're hoping to incorporate all

333
00:15:01,370 --> 00:15:00,180
the possible interactions between these

334
00:15:02,030 --> 00:15:01,380
species

335
00:15:05,750 --> 00:15:02,040
um

336
00:15:08,449 --> 00:15:05,760
which is really critical I want to re re

337
00:15:10,730 --> 00:15:08,459
uh iterate because you know the

338
00:15:13,370 --> 00:15:10,740

competition can kill off like all of the

339
00:15:16,009 --> 00:15:13,380
life you know so we need to sort of have

340
00:15:18,050 --> 00:15:16,019
an evolutionary perspective also and not

341
00:15:21,230 --> 00:15:18,060
just like a real-time ecological

342
00:15:23,509 --> 00:15:21,240
perspective to assess these things

343
00:15:26,050 --> 00:15:23,519
um so really good question

344
00:15:28,790 --> 00:15:26,060
thank you

345
00:15:31,069 --> 00:15:28,800
very quick questions

346
00:15:32,689 --> 00:15:31,079
hi Emily bear Stanford University I was

347
00:15:35,090 --> 00:15:32,699
wondering so in the biological part of

348
00:15:36,710 --> 00:15:35,100
the model what kind of data goes into

349
00:15:39,290 --> 00:15:36,720
that and how can environmental

350
00:15:40,670 --> 00:15:39,300
microbiologists help modelers improve

351
00:15:43,730 --> 00:15:40,680
their models what kind of data do you

352
00:15:46,490 --> 00:15:43,740
need for that right so we need Earth

353
00:15:48,710 --> 00:15:46,500
analogs primarily we need the you know

354
00:15:52,009 --> 00:15:48,720
catabolic reaction parameters

355
00:15:53,689 --> 00:15:52,019
for specific Earth analog so you know we

356
00:15:55,329 --> 00:15:53,699
might want to go to Antarctica and see

357
00:15:58,129 --> 00:15:55,339
what's going on there

358
00:16:00,290 --> 00:15:58,139
and that's our best that's our best way

359
00:16:02,629 --> 00:16:00,300
to constrain it at the moment

360
00:16:06,769 --> 00:16:02,639
so that's how I think biologists really

361
00:16:09,769 --> 00:16:06,779
should really help us in that way

362
00:16:11,269 --> 00:16:09,779
yeah exactly