



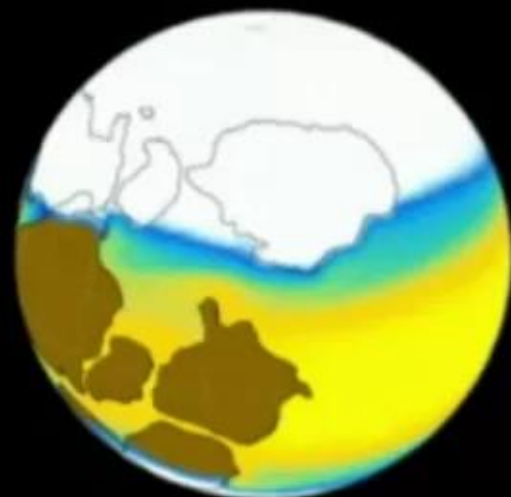
Demonstrates Albedo and Sophisticated Ocean-Atmospheric Feedback Response

Model Output Appears Robust and Validated by Geological Record of Snowball Earth

Snowball Earth Extinction Event Immediately Prior to Cambrian Association and Associated With the Oxygen Catastrophe and Deposition of Iron Banding



Solar System Calibration Model
Normalized to ECHAM 5
Coupled Ocean-Atmosphere
Chemical Model Output



1
00:00:07,670 --> 00:00:05,920

[Music]

2
00:00:09,320 --> 00:00:07,680

today we're going to tell you about our

3
00:00:12,259 --> 00:00:09,330

proposal that we propose this weekend at

4
00:00:14,089 --> 00:00:12,269

our FG and it involves two models both

5
00:00:16,160 --> 00:00:14,099

related to water worlds

6
00:00:19,040 --> 00:00:16,170

the first model that we're going to talk

7
00:00:20,420 --> 00:00:19,050

about is a planet migration model that

8
00:00:22,870 --> 00:00:20,430

explains the formation of the water

9
00:00:26,960 --> 00:00:22,880

world and then Richard will talk about a

10
00:00:30,160 --> 00:00:26,970

more chemistry based planet model when

11
00:00:31,970 --> 00:00:30,170

we get to him so just a little

12
00:00:34,010 --> 00:00:31,980

definition of what we mean by water

13
00:00:36,400 --> 00:00:34,020

world we're talking about super sized

14

00:00:38,930 --> 00:00:36,410

planets so between 1 & 8 Earth masses

15

00:00:41,990 --> 00:00:38,940

that are composed of at least 30% water

16

00:00:44,119 --> 00:00:42,000

so these are deep surface oceans that

17

00:00:45,590 --> 00:00:44,129

we're seeing in these planets the

18

00:00:48,650 --> 00:00:45,600

observational signature of a planet like

19

00:00:51,139 --> 00:00:48,660

this would be a low-density and if we

20

00:00:53,299 --> 00:00:51,149

could get a spectrum in the atmosphere

21

00:00:55,400 --> 00:00:53,309

we would hopefully notice some water

22

00:00:57,709 --> 00:00:55,410

vapor in the spectrum and so this

23

00:01:00,560 --> 00:00:57,719

proposal was a response to the NASA

24

00:01:02,569 --> 00:01:00,570

probes exobiology call and specifically

25

00:01:04,460 --> 00:01:02,579

we're looking at exploring the range of

26
00:01:09,380 --> 00:01:04,470
planetary environments and amenable to

27
00:01:12,440 --> 00:01:09,390
life so you all saw this plot yesterday

28
00:01:14,330 --> 00:01:12,450
but basically what it's showing is some

29
00:01:17,149 --> 00:01:14,340
lines of constant composition on a mass

30
00:01:21,620 --> 00:01:17,159
radius diagram for known exoplanets

31
00:01:22,969 --> 00:01:21,630
known terrestrial exoplanets and what we

32
00:01:26,719 --> 00:01:22,979
notice here is that a lot of them are

33
00:01:29,719 --> 00:01:26,729
very low-density up here on this line of

34
00:01:30,999 --> 00:01:29,729
water density and we expected to see

35
00:01:33,319 --> 00:01:31,009
that because we see a lot of low density

36
00:01:35,569 --> 00:01:33,329
planets and moons in our outer solar

37
00:01:37,310 --> 00:01:35,579
system but what we didn't expect was

38
00:01:40,550 --> 00:01:37,320

that some of these are found really

39

00:01:43,249 --> 00:01:40,560

close to their stars and particularly GJ

40

00:01:45,770 --> 00:01:43,259

1214b is a planet that is in the

41

00:01:48,499 --> 00:01:45,780

habitable zone of its star and seems to

42

00:01:54,160 --> 00:01:48,509

have a very low density and is a really

43

00:01:57,080 --> 00:01:54,170

good possible option for a water world

44

00:01:59,569 --> 00:01:57,090

and so the other thing that is

45

00:02:01,880 --> 00:01:59,579

interesting is right now observational

46

00:02:04,069 --> 00:02:01,890

biases make it so that it's difficult to

47

00:02:08,960 --> 00:02:04,079

find habitable zone earth sized planets

48

00:02:11,660 --> 00:02:08,970

so this plot shows the detection

49

00:02:13,250 --> 00:02:11,670

completeness of our current X Planet

50

00:02:13,740 --> 00:02:13,260

surveys and you can see that this

51
00:02:17,130 --> 00:02:13,750
section

52
00:02:18,570 --> 00:02:17,140
here where earth is is pretty empty

53
00:02:20,460 --> 00:02:18,580
there's it's really hard to find those

54
00:02:21,360 --> 00:02:20,470
planets so in the near future we're

55
00:02:23,550 --> 00:02:21,370
gonna start finding a lot more

56
00:02:27,180 --> 00:02:23,560
super-sized planets in the habitable

57
00:02:28,650 --> 00:02:27,190
zone of their stars and hopefully some

58
00:02:29,670 --> 00:02:28,660
of them we will discover our water

59
00:02:33,330 --> 00:02:29,680
worlds and so that's kind of what we're

60
00:02:36,390 --> 00:02:33,340
going to look into and so the way that

61
00:02:38,250 --> 00:02:36,400
you create a water world there are a few

62
00:02:40,640 --> 00:02:38,260
different ways but the tricky part is

63
00:02:42,600 --> 00:02:40,650

that it's tough to get enough water to

64

00:02:45,000 --> 00:02:42,610

create this water world in the inner

65

00:02:48,750 --> 00:02:45,010

solar system so what we're proposing is

66

00:02:50,580 --> 00:02:48,760

a method described by Raymond at all in

67

00:02:52,740 --> 00:02:50,590

which you form the water world

68

00:02:55,170 --> 00:02:52,750

late and plug the planet formation stage

69

00:02:57,390 --> 00:02:55,180

in the outer solar system and then it

70

00:03:00,240 --> 00:02:57,400

migrates in in the wake of a migrating

71

00:03:03,660 --> 00:03:00,250

hot Jupiter and so this is an n-body

72

00:03:05,310 --> 00:03:03,670

simulation run by Raymond at all in

73

00:03:08,790 --> 00:03:05,320

which a hot Jupiter is migrating through

74

00:03:10,199 --> 00:03:08,800

a gas disc inward and planetesimals are

75

00:03:13,320 --> 00:03:10,209

getting caught in resonance behind the

76
00:03:20,970 --> 00:03:13,330
hot Jupiter to result in a habitable

77
00:03:22,620 --> 00:03:20,980
zone water rich planet so for our models

78
00:03:24,960 --> 00:03:22,630
we're going to be looking at the Alpha

79
00:03:27,210 --> 00:03:24,970
Centauri system and so we chose these

80
00:03:30,509 --> 00:03:27,220
stars because they all have very similar

81
00:03:33,920 --> 00:03:30,519
composition so the we can treat the disk

82
00:03:36,210 --> 00:03:33,930
composition gradient as a constant and

83
00:03:38,910 --> 00:03:36,220
they have a range of different stellar

84
00:03:41,640 --> 00:03:38,920
types for us to use for our models but

85
00:03:44,400 --> 00:03:41,650
for the actual models this is a triple

86
00:03:47,190 --> 00:03:44,410
system but we're going to treat this as

87
00:03:49,560 --> 00:03:47,200
three independent star systems and just

88
00:03:53,850 --> 00:03:49,570

use these stars as the initial

89

00:03:57,539 --> 00:03:53,860

conditions for our for our models so the

90

00:03:59,970 --> 00:03:57,549

the first star part of our proposal is

91

00:04:01,490 --> 00:03:59,980

to set up a suite of n-body simulations

92

00:04:04,050 --> 00:04:01,500

kind of like the Raymond at all paper

93

00:04:07,670 --> 00:04:04,060

but to explore a range of different

94

00:04:09,930 --> 00:04:07,680

initial conditions for the disk

95

00:04:11,850 --> 00:04:09,940

composition and well the disk

96

00:04:14,069 --> 00:04:11,860

composition will keep constant between

97

00:04:15,240 --> 00:04:14,079

all our simulations but will change the

98

00:04:17,310 --> 00:04:15,250

initial positions of all of the

99

00:04:21,719 --> 00:04:17,320

planetesimals and the the number of

100

00:04:24,029 --> 00:04:21,729

planetesimals in the disk and yeah so

101
00:04:26,910 --> 00:04:24,039
then we'll run that these simulations

102
00:04:30,000 --> 00:04:26,920
for about 100 to 500 million years

103
00:04:31,680 --> 00:04:30,010
and end up with hopefully some of them

104
00:04:35,040 --> 00:04:31,690
will form water worlds in the habitable

105
00:04:36,720 --> 00:04:35,050
zone of their star and we'll end up with

106
00:04:38,880 --> 00:04:36,730
orbital elements for each of these water

107
00:04:40,980 --> 00:04:38,890
worlds and some physical properties that

108
00:04:46,590 --> 00:04:40,990
can be fed into the next model which

109
00:04:50,100 --> 00:04:46,600
Richard will tell you about okay thank

110
00:04:52,140 --> 00:04:50,110
you very much so we're gonna go ahead

111
00:04:54,120 --> 00:04:52,150
and take the parameters from though the

112
00:04:56,310 --> 00:04:54,130
orbital parameters from the initial

113
00:04:59,490 --> 00:04:56,320

model as well as the physical dynamics

114

00:05:01,590 --> 00:04:59,500

of each water world and take those

115

00:05:03,540 --> 00:05:01,600

parameters and plug them into a GCM

116

00:05:05,700 --> 00:05:03,550

we'll talk about that here right off the

117

00:05:07,170 --> 00:05:05,710

but but before we do that before I make

118

00:05:09,090 --> 00:05:07,180

extrapolation is to try and determine

119

00:05:11,730 --> 00:05:09,100

what are the parameters of habitability

120

00:05:13,890 --> 00:05:11,740

for an exoplanet over a spectrum of

121

00:05:16,140 --> 00:05:13,900

different types of stars it becomes

122

00:05:18,330 --> 00:05:16,150

imperative that I think that we actually

123

00:05:21,930 --> 00:05:18,340

constrain our models with real world

124

00:05:23,760 --> 00:05:21,940

data with the launch of Geneva's T and T

125

00:05:25,830 --> 00:05:23,770

and test that becomes even more

126
00:05:27,630 --> 00:05:25,840
imperative because if a person was to

127
00:05:29,490 --> 00:05:27,640
make extrapolations regarding an

128
00:05:31,890 --> 00:05:29,500
exoplanet without constraining their

129
00:05:34,590 --> 00:05:31,900
model with real world data that becomes

130
00:05:38,070 --> 00:05:34,600
nebulous and it runs a little bit on the

131
00:05:41,160 --> 00:05:38,080
side of hinky okay I think that's a

132
00:05:44,010 --> 00:05:41,170
scientific term so how do we do this

133
00:05:45,180 --> 00:05:44,020
then in our proposal we state that what

134
00:05:48,210 --> 00:05:45,190
we're gonna do is we're going to try to

135
00:05:50,190 --> 00:05:48,220
work with the model parameters to try

136
00:05:52,560 --> 00:05:50,200
and validate our models utilizing world

137
00:05:54,780 --> 00:05:52,570
data fortunately we have now several

138
00:05:56,340 --> 00:05:54,790

decades of data regarding terrestrial

139

00:05:58,680 --> 00:05:56,350

planets that exist within the habitable

140

00:06:00,960 --> 00:05:58,690

zone is everybody here already knows so

141

00:06:03,960 --> 00:06:00,970

we take the our solar system as the

142

00:06:07,530 --> 00:06:03,970

model we run our Hubble's own validation

143

00:06:10,560 --> 00:06:07,540

for the spectrum of the habit of zone

144

00:06:11,880 --> 00:06:10,570

Venus Earth and Mars and then bracket

145

00:06:13,410 --> 00:06:11,890

with an outlier which we'll talk about

146

00:06:15,180 --> 00:06:13,420

which will be tightened so I'm only

147

00:06:17,190 --> 00:06:15,190

gonna run briefly through this but what

148

00:06:20,070 --> 00:06:17,200

I want to impress is that in terms of

149

00:06:22,470 --> 00:06:20,080

the model validation we use royal data

150

00:06:24,900 --> 00:06:22,480

to explore habitability within our own

151
00:06:27,210 --> 00:06:24,910
solar system where we know that there's

152
00:06:29,460 --> 00:06:27,220
abundant life at least on earth there

153
00:06:33,390 --> 00:06:29,470
may have been potentially early life on

154
00:06:36,900 --> 00:06:33,400
Venus that's the idea and then Mars at

155
00:06:39,940 --> 00:06:36,910
least is marginal at best so to start

156
00:06:45,310 --> 00:06:39,950
here we have of course the

157
00:06:47,230 --> 00:06:45,320
spectrum of Earth Venus and Mars the

158
00:06:48,640 --> 00:06:47,240
abiotic systems tend to run towards a

159
00:06:51,610 --> 00:06:48,650
thermodynamic equilibrium and you see a

160
00:06:54,760 --> 00:06:51,620
clear co2 signal Mars house is a little

161
00:06:56,530 --> 00:06:54,770
bit of nebulous issues regarding methane

162
00:06:59,170 --> 00:06:56,540
the may or may not be biotic depending

163
00:07:00,940 --> 00:06:59,180

on what set of camp you fall into but it

164

00:07:04,660 --> 00:07:00,950

does bracket the outside portion of

165

00:07:06,370 --> 00:07:04,670

habitability when it comes to earth it's

166

00:07:07,840 --> 00:07:06,380

very important to go ahead and constrain

167

00:07:09,220 --> 00:07:07,850

the Earth's system and say okay what is

168

00:07:11,350 --> 00:07:09,230

the minimum on a day that we need to

169

00:07:13,900 --> 00:07:11,360

really look at our planet which is a

170

00:07:15,460 --> 00:07:13,910

known thriving biosphere that

171

00:07:18,370 --> 00:07:15,470

interconnects all the different systems

172

00:07:20,980 --> 00:07:18,380

on the planet and actually modify the

173

00:07:23,560 --> 00:07:20,990

planet can we see an unambiguous signal

174

00:07:24,510 --> 00:07:23,570

if we examine our own planet as an

175

00:07:26,470 --> 00:07:24,520

exoplanet

176

00:07:29,430 --> 00:07:26,480

fortunately great works been done on

177

00:07:33,610 --> 00:07:29,440

this by the Robinson a tall team in 2011

178

00:07:35,830 --> 00:07:33,620

during the Deep Impact survey of a comet

179

00:07:37,270 --> 00:07:35,840

they were really sharp and they turned

180

00:07:38,140 --> 00:07:37,280

the cameras back around and looked at

181

00:07:40,900 --> 00:07:38,150

our own planet

182

00:07:42,430 --> 00:07:40,910

and basically looked at our planet just

183

00:07:45,010 --> 00:07:42,440

like a technological society we look at

184

00:07:46,300 --> 00:07:45,020

our planet to determine if that's a

185

00:07:48,490 --> 00:07:46,310

habitable planet and how much data could

186

00:07:51,940 --> 00:07:48,500

we extract out of a hundred meter or

187

00:07:53,440 --> 00:07:51,950

excuse me a 100 pixel survey so if you

188

00:07:54,970 --> 00:07:53,450

look at our planet we can actually learn

189

00:07:58,660 --> 00:07:54,980

quite a bit just from a little bit of

190

00:08:01,360 --> 00:07:58,670

data and we can quantify our system in

191

00:08:04,740 --> 00:08:01,370

terms of surface features including

192

00:08:07,870 --> 00:08:04,750

ratios of land mass versus ocean

193

00:08:09,820 --> 00:08:07,880

approximately 50 percent cloud cover run

194

00:08:13,030 --> 00:08:09,830

that through time combine that with

195

00:08:15,460 --> 00:08:13,040

spectroscopic work and lo and behold bio

196

00:08:17,040 --> 00:08:15,470

signatures pop out in terms of looking

197

00:08:19,420 --> 00:08:17,050

at the atmospheric signature

198

00:08:22,470 --> 00:08:19,430

corresponding as well to habitability of

199

00:08:25,270 --> 00:08:22,480

ocean determination and habitability by

200

00:08:27,310 --> 00:08:25,280

composition some of the features you

201
00:08:31,390 --> 00:08:27,320
already know ad nauseum water

202
00:08:35,290 --> 00:08:31,400
a strong methane signal owes three are

203
00:08:36,460 --> 00:08:35,300
very strong features for habitability so

204
00:08:38,080 --> 00:08:36,470
what is the minimum amount of data we

205
00:08:39,550 --> 00:08:38,090
can then extract and utilize to

206
00:08:41,670 --> 00:08:39,560
determine if these planets are habitable

207
00:08:44,050 --> 00:08:41,680
we go up with with tests we go up with

208
00:08:46,120 --> 00:08:44,060
JWST that's very limited observation

209
00:08:47,500 --> 00:08:46,130
time we need to be able to maximize the

210
00:08:51,130 --> 00:08:47,510
data retrieved and be able to interpret

211
00:08:52,910 --> 00:08:51,140
so we don't Forge either a false

212
00:08:55,519 --> 00:08:52,920
negative or false positive

213
00:08:57,860 --> 00:08:55,529

this is a an image of the transit of

214

00:08:58,280 --> 00:08:57,870

Venus in front of the Sun let me back up

215

00:09:00,670 --> 00:08:58,290

a bit

216

00:09:04,340 --> 00:09:00,680

sorry turns out that you can actually

217

00:09:05,900 --> 00:09:04,350

get the profile of the atmosphere from

218

00:09:08,269 --> 00:09:05,910

this little tiny sliver here the

219

00:09:11,120 --> 00:09:08,279

atmospheric limb so four atmospheres

220

00:09:13,160 --> 00:09:11,130

that are transparent the flecks of

221

00:09:14,629 --> 00:09:13,170

photons is very low it's something on

222

00:09:16,699 --> 00:09:14,639

the order I think 100 and someone can

223

00:09:20,530 --> 00:09:16,709

correct me about 120 part per million

224

00:09:23,840 --> 00:09:20,540

photon hitting a CCD and that's over

225

00:09:26,840 --> 00:09:23,850

four parsec well four parsecs I believe

226

00:09:30,460 --> 00:09:26,850

so here's the Venus spectrum that

227

00:09:33,410 --> 00:09:30,470

wiggling in the laser pointer is coffee

228

00:09:36,079 --> 00:09:33,420

probably nerves and then you can see in

229

00:09:39,110 --> 00:09:36,089

fact that Venus has an atmospheric

230

00:09:42,470 --> 00:09:39,120

signature and now this trick note

231

00:09:44,960 --> 00:09:42,480

atmospheric city Atmospheric signature

232

00:09:46,910 --> 00:09:44,970

that is indicative of the hydrocarbons

233

00:09:47,960 --> 00:09:46,920

up in the atmosphere and we look at it

234

00:09:49,790 --> 00:09:47,970

closely you get a little bit more

235

00:09:50,960 --> 00:09:49,800

regarding circulation so this actually

236

00:09:53,740 --> 00:09:50,970

also shows a little of that mystery

237

00:09:56,449 --> 00:09:53,750

circulation that's analogous to Hadley

238

00:10:00,530 --> 00:09:56,459

on earth and water vapor at

239

00:10:02,840 --> 00:10:00,540

approximately 35 kilometers ok so then

240

00:10:05,120 --> 00:10:02,850

we've parameterised now if our models

241

00:10:07,730 --> 00:10:05,130

that we were able to build prior to

242

00:10:09,139 --> 00:10:07,740

bringing into exoplanet data we can

243

00:10:10,970 --> 00:10:09,149

parameterize and truth' them to our own

244

00:10:13,639 --> 00:10:10,980

solar system and that's vital it's a

245

00:10:16,069 --> 00:10:13,649

vital step I believe we can then also

246

00:10:18,740 --> 00:10:16,079

bracket it using a biotic system or

247

00:10:21,110 --> 00:10:18,750

prebiotic system to tighten the Titan

248

00:10:23,720 --> 00:10:21,120

system also shows methane and ethane at

249

00:10:27,769 --> 00:10:23,730

different latitudes and so again minimal

250

00:10:29,329 --> 00:10:27,779

data provides maximum output so how do

251

00:10:31,880 --> 00:10:29,339

we approach this to the exoplanet

252

00:10:33,410 --> 00:10:31,890

question the exoplanet question has a

253

00:10:36,500 --> 00:10:33,420

lot to do with models and obviously

254

00:10:38,210 --> 00:10:36,510

models have strong vulnerabilities in

255

00:10:39,949 --> 00:10:38,220

terms of their sensitivities and by

256

00:10:42,319 --> 00:10:39,959

necessity you can't put it in front of

257

00:10:44,000 --> 00:10:42,329

data into a model otherwise you end up

258

00:10:46,370 --> 00:10:44,010

warping the model and having gunk pop

259

00:10:48,710 --> 00:10:46,380

back out so we find out what are the

260

00:10:51,230 --> 00:10:48,720

most important processes and with the

261

00:10:53,750 --> 00:10:51,240

experience of students in this room and

262

00:10:55,069 --> 00:10:53,760

others in the community I feel confident

263

00:10:56,930 --> 00:10:55,079

that we can actually parameterize our

264

00:10:58,910 --> 00:10:56,940

solar system and utilize those

265

00:11:02,030 --> 00:10:58,920

parameters and then plug them into an

266

00:11:04,130 --> 00:11:02,040

exoplanet model in terms of a couple of

267

00:11:06,440 --> 00:11:04,140

geochemical model it's possible to

268

00:11:08,240 --> 00:11:06,450

modify something that we know has

269

00:11:12,280 --> 00:11:08,250

already successfully parameterised an

270

00:11:14,720 --> 00:11:12,290

ancient world that can be ground truth

271

00:11:18,200 --> 00:11:14,730

so to look for an ancient world we go

272

00:11:21,290 --> 00:11:18,210

back in the geological record we start

273

00:11:23,150 --> 00:11:21,300

to examine the snowball earth snowball

274

00:11:25,970 --> 00:11:23,160

earth is a period of time of geological

275

00:11:27,830 --> 00:11:25,980

history where the vast majority of the

276

00:11:30,560 --> 00:11:27,840

Earth's surface was covered in ice or

277

00:11:32,780 --> 00:11:30,570

snow and pack ice which led to mass

278

00:11:36,320 --> 00:11:32,790

extinctions it's also implicated in

279

00:11:38,330 --> 00:11:36,330

subsequent biodiversity explosion now

280

00:11:40,310 --> 00:11:38,340

one of the other processes that occurred

281

00:11:42,800 --> 00:11:40,320

during that time was a shift from a

282

00:11:46,940 --> 00:11:42,810

reductive ocean atmosphere state to a

283

00:11:49,340 --> 00:11:46,950

net oxygenated atmosphere so if we can

284

00:11:50,570 --> 00:11:49,350

do that for our ancient planet who's to

285

00:11:52,550 --> 00:11:50,580

say that we can't do that for an

286

00:11:53,750 --> 00:11:52,560

exoplanet now some of you may be

287

00:11:56,690 --> 00:11:53,760

wondering say well that's a lot to take

288

00:11:58,220 --> 00:11:56,700

on why would you do 3 stars well it

289

00:11:59,930 --> 00:11:58,230

turns out is Jonathan already mentioned

290

00:12:01,250 --> 00:11:59,940

this is a very attractive system in fact

291

00:12:03,850 --> 00:12:01,260

I think should be probably the highest

292

00:12:05,960 --> 00:12:03,860

priority system look at for habitability

293

00:12:07,400 --> 00:12:05,970

one of the reasons of course is

294

00:12:09,680 --> 00:12:07,410

metallicity and is that we've seen in

295

00:12:12,740 --> 00:12:09,690

the talked prior yesterday the medalists

296

00:12:16,340 --> 00:12:12,750

key constraints obviously the relative

297

00:12:19,790 --> 00:12:16,350

elemental abundance on the subsequent

298

00:12:21,530 --> 00:12:19,800

planets however another issue is that

299

00:12:24,170 --> 00:12:21,540

you have three stars starting from a

300

00:12:26,780 --> 00:12:24,180

initial homogenous state that evolved

301

00:12:29,300 --> 00:12:26,790

and diversify over time but if you look

302

00:12:31,960 --> 00:12:29,310

here the spectral types are very similar

303

00:12:35,840 --> 00:12:31,970

to earth you have a star that brackets

304

00:12:37,990 --> 00:12:35,850

our own Sun's habitability and system in

305

00:12:40,370 --> 00:12:38,000

a case system and then Proxima Centauri

306

00:12:43,880 --> 00:12:40,380

so what are the limits and vulnerability

307

00:12:45,850 --> 00:12:43,890

in a water world around those stars we

308

00:12:49,010 --> 00:12:45,860

can modify and we can go ahead and mix

309

00:12:50,360 --> 00:12:49,020

some analyses to determine what a water

310

00:12:52,970 --> 00:12:50,370

world would look like but I would argue

311

00:12:54,470 --> 00:12:52,980

that there's an interval of water worlds

312

00:12:57,110 --> 00:12:54,480

that we can evolve around stars that are

313

00:12:58,970 --> 00:12:57,120

not only habitable but super habitable

314

00:13:04,010 --> 00:12:58,980

for reasons that we can discuss maybe

315

00:13:04,780 --> 00:13:04,020

one on one is a function of time so what

316

00:13:06,680 --> 00:13:04,790

is this all about

317

00:13:08,300 --> 00:13:06,690

ultimately it's to try and determine

318

00:13:10,580 --> 00:13:08,310

what is a spectral characteristic of

319

00:13:13,490 --> 00:13:10,590

hypothetical planets driven by abiotic

320

00:13:15,350 --> 00:13:13,500

processes you can form both an

321

00:13:18,500 --> 00:13:15,360

oxygenating atmosphere as well as

322

00:13:20,480 --> 00:13:18,510

reducing ocean atmosphere system without

323

00:13:22,280 --> 00:13:20,490

invoking biotic process

324

00:13:25,070 --> 00:13:22,290

so when we see that signal for that one

325

00:13:27,410 --> 00:13:25,080

pixel data let's go ahead and interpret

326

00:13:32,120 --> 00:13:27,420

that as a starting starting point for

327

00:13:33,260 --> 00:13:32,130

subsequent studies and just really

328

00:13:35,990 --> 00:13:33,270

quickly because I think we're out of

329

00:13:38,860 --> 00:13:36,000

time this is our 3-year plan basically

330

00:13:41,390 --> 00:13:38,870

the the first model we described will be

331

00:13:43,880 --> 00:13:41,400

built in and run over the first two

332

00:13:45,440 --> 00:13:43,890

years and while the second model is

333

00:13:47,450 --> 00:13:45,450

simultaneously being built and

334

00:13:48,530 --> 00:13:47,460

calibrated and then in the third year

335

00:13:50,690 --> 00:13:48,540

will be applied to the Alpha Centauri

336

00:13:51,950 --> 00:13:50,700

system and so lastly I just want to

337

00:13:53,600 --> 00:13:51,960

thank everyone that was involved in the

338

00:13:55,670 --> 00:13:53,610

RF G this weekend it was a ton of fun

339

00:13:58,370 --> 00:13:55,680

and I'd specifically want to thank the

340

00:13:58,880 --> 00:13:58,380

organizers who really threw us off the

341

00:14:01,910 --> 00:13:58,890

deep end

342

00:14:03,800 --> 00:14:01,920

and gave us a chance to to really get

343

00:14:05,780 --> 00:14:03,810

into the proposal writing process and I

344

00:14:09,400 --> 00:14:05,790

didn't have any pictures so I took some

345

00:14:53,350 --> 00:14:09,410

yesterday thank you

346

00:14:57,560 --> 00:14:56,180

so we didn't get too much of a chance to

347

00:14:59,300 --> 00:14:57,570

talk about the actual model so the model

348

00:15:02,389 --> 00:14:59,310

actually incorporates atmosphere it's on

349

00:15:04,610 --> 00:15:02,399

a 42 level atmospheric coupled model to

350

00:15:05,660 --> 00:15:04,620

ocean atmosphere communication so I'm

351

00:15:06,860 --> 00:15:05,670

aware of what you're talking about

352

00:15:08,269 --> 00:15:06,870

there's some issues in terms of

353

00:15:09,680 --> 00:15:08,279

habitability of water worlds because

354

00:15:11,240 --> 00:15:09,690

it's a function of mass and it's a

355

00:15:13,970 --> 00:15:11,250

stepwise transition about one point six

356

00:15:16,819 --> 00:15:13,980

earth mass from a potentially habitable

357

00:15:18,139 --> 00:15:16,829

world to more of a Newtonian system

358

00:15:19,730 --> 00:15:18,149

where you retain some of those light

359

00:15:22,490 --> 00:15:19,740

hydrocarbons they also form a

360

00:15:24,110 --> 00:15:22,500

supercritical vapour liquid phase so

361

00:15:25,639 --> 00:15:24,120

habitability is also a question you can

362

00:15:26,870 --> 00:15:25,649

consider habitability may be a function

363

00:15:28,519 --> 00:15:26,880

of terrestrial habitats may not

364

00:15:30,560 --> 00:15:28,529

necessarily be the outlook to look for

365

00:15:31,759 --> 00:15:30,570

but I do agree with you and I think you

366

00:15:33,319 --> 00:15:31,769

made a comment yesterday about

367

00:15:35,720 --> 00:15:33,329

habitability should be expanded because

368

00:15:37,850 --> 00:15:35,730

it is also the issue of icy worlds and