
Jack Madden
1D Exoplanet Habitability:
Now in Technicolor!

1
00:00:00,240 --> 00:00:10,930
[Music]

2
00:00:17,420 --> 00:00:14,570
one thing I like about AB grad con is

3
00:00:20,060 --> 00:00:17,430
the audiences is pretty chill so we're

4
00:00:22,610 --> 00:00:20,070
all grad students undergrads so I get to

5
00:00:24,830 --> 00:00:22,620
experiment with how I do presentations

6
00:00:26,570 --> 00:00:24,840
so I need first I need some audience

7
00:00:32,630 --> 00:00:26,580
participation

8
00:00:37,759 --> 00:00:32,640
can someone give me a letter hey Jay

9
00:00:44,599 --> 00:00:37,769
okay another lender okay now a number

10
00:00:48,619 --> 00:00:44,609
between one mm I knew someone was gonna

11
00:00:54,559 --> 00:00:48,629
say that I'm gonna go with 13 another

12
00:01:00,099 --> 00:00:54,569
letter you okay this is great

13
00:01:01,399 --> 00:01:00,109

all right now hot or cold hot all right

14
00:01:05,320 --> 00:01:01,409
perfect

15
00:01:07,340 --> 00:01:05,330
okay so I'm going to talk about color

16
00:01:10,160 --> 00:01:07,350
I'm gonna be talking about in a couple

17
00:01:13,130 --> 00:01:10,170
of contexts all related to exoplanet

18
00:01:16,010 --> 00:01:13,140
habitability I'll be talking about how

19
00:01:18,020 --> 00:01:16,020
we can use it to classify things now and

20
00:01:22,010 --> 00:01:18,030
how I'm using it in some models to

21
00:01:24,470 --> 00:01:22,020
classify things in a future and I want

22
00:01:29,710 --> 00:01:24,480
to do it or telling the story of a

23
00:01:33,200 --> 00:01:29,720
planet just recently discovered JC 13q

24
00:01:35,420 --> 00:01:33,210
meaning it's there's many planets in

25
00:01:37,160 --> 00:01:35,430
this system it's probably the most

26
00:01:39,590 --> 00:01:37,170
impressive planetary system ever

27
00:01:42,860 --> 00:01:39,600
discovered and it has this habitable

28
00:01:45,290 --> 00:01:42,870
planet it's totally real it's there it's

29
00:01:47,900 --> 00:01:45,300
got life teeming on it but how are we

30
00:01:52,640 --> 00:01:47,910
gonna know how do we figure out that

31
00:01:55,040 --> 00:01:52,650
it's there so right now we can't really

32
00:01:58,700 --> 00:01:55,050
make detection zuv what the composition

33
00:02:00,560 --> 00:01:58,710
yeah this feels like we have a range you

34
00:02:03,050 --> 00:02:00,570
know we can detect habitability out to

35
00:02:06,110 --> 00:02:03,060
like zero lightyears

36
00:02:09,150 --> 00:02:06,120
so this planets much further than that

37
00:02:12,150 --> 00:02:09,160
so what we can do now is we sort of can

38
00:02:15,150 --> 00:02:12,160

make guesses and leader people like

39
00:02:16,830 --> 00:02:15,160
Claire will you know use telescopes to

40
00:02:19,350 --> 00:02:16,840
actually make the detection and confirm

41
00:02:22,080 --> 00:02:19,360
our guesses so as we build up these

42
00:02:25,980 --> 00:02:22,090
guesses we're sort of building a library

43
00:02:28,140 --> 00:02:25,990
of sort of pictures of what potentially

44
00:02:29,760 --> 00:02:28,150
habitable planets could look like and

45
00:02:32,010 --> 00:02:29,770
then we have this reference catalog it's

46
00:02:33,720 --> 00:02:32,020
like sort of like an Autobahn guide like

47
00:02:35,250 --> 00:02:33,730
we're building up you know reference

48
00:02:36,660 --> 00:02:35,260
pictures and then you go out in the wild

49
00:02:40,710 --> 00:02:36,670
you actually observe something and you

50
00:02:42,810 --> 00:02:40,720
try to match it as close as you can so

51
00:02:44,240 --> 00:02:42,820
the first thing you sort of want to do

52
00:02:46,770 --> 00:02:44,250
is you want to have like ground truths

53
00:02:49,110 --> 00:02:46,780
to what you wanted to do first we need

54
00:02:51,300 --> 00:02:49,120
to actually find some real planets and

55
00:02:53,640 --> 00:02:51,310
what do those look like first so we have

56
00:02:56,360 --> 00:02:53,650
a solar system that's pretty diverse we

57
00:03:00,510 --> 00:02:56,370
do have a habitable planet which is nice

58
00:03:03,180 --> 00:03:00,520
so some of the earlier work we did was

59
00:03:06,420 --> 00:03:03,190
actually look at our neighbors stuff in

60
00:03:09,180 --> 00:03:06,430
our own solar system to see what they'd

61
00:03:11,360 --> 00:03:09,190
look like as exoplanets so we calculated

62
00:03:14,130 --> 00:03:11,370
geometric adios for the 19 different

63
00:03:16,200 --> 00:03:14,140

solar system objects you you know the

64
00:03:19,740 --> 00:03:16,210
planets some dwarf planets a bunch of

65
00:03:21,150 --> 00:03:19,750
moons to sort of build this you know

66
00:03:24,600 --> 00:03:21,160
picture of what our solar system looks

67
00:03:26,900 --> 00:03:24,610
like and then we use that to model what

68
00:03:28,760 --> 00:03:26,910
they would look like around other stars

69
00:03:32,640 --> 00:03:28,770
and here's our

70
00:03:34,500 --> 00:03:32,650
JC 13 cute is down here so it doesn't

71
00:03:38,280 --> 00:03:34,510
have the spectra of x3 when I figure out

72
00:03:39,449 --> 00:03:38,290
what that's gonna be like so we reaffirm

73
00:03:41,370 --> 00:03:39,459
and rip one of the things that you can

74
00:03:42,750 --> 00:03:41,380
do with just something as simple as

75
00:03:44,520 --> 00:03:42,760
looking at our own solar system and

76
00:03:46,350 --> 00:03:44,530
that's distinguishing different types of

77
00:03:48,420 --> 00:03:46,360
surfaces it's gonna be one of the first

78
00:03:52,199 --> 00:03:48,430
steps when you find an exoplanets here's

79
00:03:54,420 --> 00:03:52,209
a rocky as a gaseous as an icy so even

80
00:03:56,580 --> 00:03:54,430
with something as simple as one of these

81
00:04:00,540 --> 00:03:56,590
colors so people might not be familiar

82
00:04:03,890 --> 00:04:00,550
with this rnj these are just different

83
00:04:06,570 --> 00:04:03,900
filter bands you essentially just take

84
00:04:08,820 --> 00:04:06,580
your spectra of the planet you have a

85
00:04:12,270 --> 00:04:08,830
filter man you just integrate over that

86
00:04:13,680 --> 00:04:12,280
and it's just this broad broad spectra

87
00:04:16,590 --> 00:04:13,690
thank you think of like a very low

88
00:04:18,550 --> 00:04:16,600

resolution spectra and this is just you

89
00:04:20,710 --> 00:04:18,560
know a reddish color and this is

90
00:04:23,590 --> 00:04:20,720
for red and here's a couple more

91
00:04:25,390 --> 00:04:23,600
infrared so even with this very low

92
00:04:28,480 --> 00:04:25,400
resolution spectral data you can

93
00:04:31,150 --> 00:04:28,490
distinguish different surface types so

94
00:04:34,600 --> 00:04:31,160
it's something we can do using objects

95
00:04:37,890 --> 00:04:34,610
in our own solar system but there's this

96
00:04:41,020 --> 00:04:37,900
can only go so far so if you have a

97
00:04:43,500 --> 00:04:41,030
planet that has any sort of atmosphere

98
00:04:45,190 --> 00:04:43,510
and you change the light source that

99
00:04:48,280 --> 00:04:45,200
chemistry is going to be a little

100
00:04:50,860 --> 00:04:48,290
different we can do things you know for

101
00:04:52,000 --> 00:04:50,870
rocky planets like that don't have much

102
00:04:54,280 --> 00:04:52,010
of an atmosphere that's not gonna change

103
00:04:56,590 --> 00:04:54,290
much in terms of its colors if you put

104
00:04:57,790 --> 00:04:56,600
on a different star you can adjust for

105
00:04:59,680 --> 00:04:57,800
how the lights going to be different

106
00:05:02,500 --> 00:04:59,690
there's no chemistry really changing the

107
00:05:05,980 --> 00:05:02,510
atmosphere because there isn't any so if

108
00:05:08,860 --> 00:05:05,990
you really want to look at something

109
00:05:12,700 --> 00:05:08,870
like our planet which is around a hot

110
00:05:15,250 --> 00:05:12,710
star so it's a lot hotter than our own

111
00:05:19,540 --> 00:05:15,260
Sun so the light that's hitting it's

112
00:05:22,210 --> 00:05:19,550
going to be different so if you look at

113
00:05:24,340 --> 00:05:22,220

the models that we're using to simulate

114
00:05:28,260 --> 00:05:24,350
what those atmospheres would look like

115
00:05:30,670 --> 00:05:28,270
for habitable exoplanets we find that

116
00:05:34,330 --> 00:05:30,680
they're they're sort of not good enough

117
00:05:36,279 --> 00:05:34,340
they do do the job of changing the

118
00:05:39,190 --> 00:05:36,289
chemistry of the atmosphere you can sort

119
00:05:42,730 --> 00:05:39,200
of model how that that light is going to

120
00:05:45,070 --> 00:05:42,740
change the chemistry but they they lack

121
00:05:49,719 --> 00:05:45,080
another key feature which is the surface

122
00:05:52,210 --> 00:05:49,729
albedo spectral information that points

123
00:05:57,490 --> 00:05:52,220
a huge role in how the climate becomes

124
00:05:59,500 --> 00:05:57,500
stable so to our model the planet kind

125
00:06:03,070 --> 00:05:59,510
of looks like this it's gray it's just

126
00:06:05,620 --> 00:06:03,080
there's no color information for the

127
00:06:07,000 --> 00:06:05,630
surface it's just a single value that

128
00:06:09,190 --> 00:06:07,010
you're using to treat the entire

129
00:06:12,250 --> 00:06:09,200
reflectivity of the surface it's a

130
00:06:14,379 --> 00:06:12,260
single number we want it to look like it

131
00:06:16,740 --> 00:06:14,389
is something like less you know much

132
00:06:20,770 --> 00:06:16,750
more close to what it's actually like

133
00:06:24,820 --> 00:06:20,780
but we do use one dimensional models so

134
00:06:25,960 --> 00:06:24,830
it's more like this and we want it to be

135
00:06:29,410 --> 00:06:25,970
like this

136
00:06:30,850 --> 00:06:29,420
so there's that still improvement and

137
00:06:33,610 --> 00:06:30,860
there's there's a good reason to believe

138
00:06:36,220 --> 00:06:33,620

that this just adding this color

139
00:06:39,550 --> 00:06:36,230
information for the surface is going to

140
00:06:42,600 --> 00:06:39,560
alter the climate over our planets a lot

141
00:06:46,180 --> 00:06:42,610
so I'll do a little bit more complicated

142
00:06:50,100 --> 00:06:46,190
albedo diagram than what amber showed so

143
00:06:53,170 --> 00:06:50,110
we have our Sun here you know all the

144
00:06:55,560 --> 00:06:53,180
incoming energy is hitting the planet

145
00:06:57,820 --> 00:06:55,570
here which is gray have our atmosphere

146
00:07:00,460 --> 00:06:57,830
and so what all these lines are telling

147
00:07:01,930 --> 00:07:00,470
you is like there's you know hitting the

148
00:07:04,120 --> 00:07:01,940
top of the atmosphere we have all the

149
00:07:05,980 --> 00:07:04,130
energy from the Sun there's some being

150
00:07:07,930 --> 00:07:05,990
absorbed by the atmosphere and reflected

151
00:07:09,640 --> 00:07:07,940
off some is being absorbed by the

152
00:07:12,040 --> 00:07:09,650
surface somes being reflected by the

153
00:07:15,040 --> 00:07:12,050
surface and here we have longer

154
00:07:18,250 --> 00:07:15,050
wavelengths the infrared being emitted

155
00:07:19,780 --> 00:07:18,260
from the warm surface absorbed by the

156
00:07:22,810 --> 00:07:19,790
atmosphere and re-emitted by the

157
00:07:28,980 --> 00:07:22,820
atmosphere or then directly you know

158
00:07:33,760 --> 00:07:28,990
radiated out into space so if we change

159
00:07:35,500 --> 00:07:33,770
the Starlight that's good we have a gray

160
00:07:38,820 --> 00:07:35,510
planet here so we don't have any

161
00:07:40,990 --> 00:07:38,830
interaction between the albedo and the

162
00:07:42,850 --> 00:07:41,000
changing star like it's gonna be pretty

163
00:07:46,300 --> 00:07:42,860

much the same we can model how the

164
00:07:49,630 --> 00:07:46,310
atmosphere is going to change here if we

165
00:07:52,780 --> 00:07:49,640
add color to the planet now we don't

166
00:07:54,190 --> 00:07:52,790
know exactly how you know there's going

167
00:07:56,110 --> 00:07:54,200
to be changes in how much is getting

168
00:07:57,850 --> 00:07:56,120
absorbed by the surface what's being

169
00:08:00,130 --> 00:07:57,860
reflected and that's it going to be

170
00:08:02,200 --> 00:08:00,140
affecting how much is then being reread

171
00:08:04,630 --> 00:08:02,210
yet but a surface and then escaping into

172
00:08:07,390 --> 00:08:04,640
space and this is where you're setting

173
00:08:09,610 --> 00:08:07,400
habitability constraints as well because

174
00:08:12,159 --> 00:08:09,620
you this is controlling you order

175
00:08:13,600 --> 00:08:12,169
surface temperature and that's gonna be

176
00:08:15,400 --> 00:08:13,610
what you need for habitability in them

177
00:08:18,040 --> 00:08:15,410
I'm saying habitability I should define

178
00:08:20,050 --> 00:08:18,050
that like surface water if you have

179
00:08:24,990 --> 00:08:20,060
water on the surface we'll call that

180
00:08:28,919 --> 00:08:25,000
habitable so to look at this in more

181
00:08:33,879 --> 00:08:33,100
we have different star spectra here so

182
00:08:36,939 --> 00:08:33,889
our planet

183
00:08:39,459 --> 00:08:36,949
JC 13q is around a hotter star so it's

184
00:08:42,639 --> 00:08:39,469
gonna be like an F star this is gonna be

185
00:08:45,850 --> 00:08:42,649
this spectra here we have microns 0.5 to

186
00:08:48,069 --> 00:08:45,860
2.5 s this is your infrared and this is

187
00:08:49,749 --> 00:08:48,079
this the relative flux for these

188
00:08:54,840 --> 00:08:49,759

different stars you have the Sun here in

189
00:08:57,699 --> 00:08:54,850
white and then a cooler start here red

190
00:08:59,170 --> 00:08:57,709
so you can see that they're emitting the

191
00:09:01,290 --> 00:08:59,180
different light is gonna be playing the

192
00:09:04,449 --> 00:09:01,300
planet around these different stories

193
00:09:06,970 --> 00:09:04,459
here down here we have the reflectance

194
00:09:10,689 --> 00:09:06,980
so this is that surface color surface

195
00:09:12,490 --> 00:09:10,699
albedo I have this dashed line is the

196
00:09:16,150 --> 00:09:12,500
flat this is what the model is used

197
00:09:18,090 --> 00:09:16,160
right now it's just a gray surface it's

198
00:09:22,780 --> 00:09:18,100
reflecting exactly the same in all

199
00:09:24,490 --> 00:09:22,790
wavelengths and here I have an earth

200
00:09:27,550 --> 00:09:24,500
model that's at the resolution of what

201
00:09:32,290 --> 00:09:27,560
our models sort of look at you do the

202
00:09:34,210 --> 00:09:32,300
radiative transfer at so let's go let's

203
00:09:36,699 --> 00:09:34,220
go for this Sun let's start with the Sun

204
00:09:39,280 --> 00:09:36,709
so if the Sun spectra is hitting the

205
00:09:41,679 --> 00:09:39,290
flat that's okay that's what our models

206
00:09:43,900 --> 00:09:41,689
had all been built to do all these

207
00:09:46,090 --> 00:09:43,910
models are coming from Earth around the

208
00:09:48,670 --> 00:09:46,100
Sun they were used to simulate the

209
00:09:51,819 --> 00:09:48,680
Earth's climate and they've been sort of

210
00:09:55,780 --> 00:09:51,829
ad hoc let's just mesh together to

211
00:09:57,509 --> 00:09:55,790
create exoplanet models um so you can

212
00:10:01,300 --> 00:09:57,519
really tell that this is something that

213
00:10:02,559 --> 00:10:01,310

is left over from you know when it was

214
00:10:04,840 --> 00:10:02,569
just being used for Earth because this

215
00:10:05,949 --> 00:10:04,850
actually simulates fairly well you know

216
00:10:07,870 --> 00:10:05,959
the surface temperature that you get

217
00:10:11,650 --> 00:10:07,880
players so that's okay if we have this

218
00:10:16,600 --> 00:10:11,660
one we can use the flat fine if we

219
00:10:18,850 --> 00:10:16,610
change the star and it's still flat

220
00:10:22,240 --> 00:10:18,860
there's really not much interaction here

221
00:10:24,939 --> 00:10:22,250
it's you can you know every every change

222
00:10:28,530 --> 00:10:24,949
that's occurring is just just captured

223
00:10:33,939 --> 00:10:28,540
by the star but if we have a changing

224
00:10:36,340 --> 00:10:33,949
albedo say this Paris model you can see

225
00:10:38,280 --> 00:10:36,350
that if we change the star we're going

226
00:10:39,919 --> 00:10:38,290
to be absorbing and reflecting different

227
00:10:42,090 --> 00:10:39,929
in different parts of the spectrum now

228
00:10:46,199 --> 00:10:42,100
that's gonna be altering our surface

229
00:10:51,059 --> 00:10:46,209
temperature so if we have a cooler star

230
00:10:54,689 --> 00:10:51,069
this M star we see that we're absorbing

231
00:10:57,359 --> 00:10:54,699
more it's albedo is lower over here

232
00:10:59,609 --> 00:10:57,369
we're more the sunlight a star lights

233
00:11:01,229 --> 00:10:59,619
hitting so we're gonna be absorbing more

234
00:11:04,679 --> 00:11:01,239
there so the planet should be hotter

235
00:11:07,229 --> 00:11:04,689
than if we had just used a flat and if

236
00:11:10,289 --> 00:11:07,239
we're around the star that our planets

237
00:11:12,900 --> 00:11:10,299
around where a lot of the flux is at

238
00:11:15,599 --> 00:11:12,910

these lower wavelengths or B we're

239
00:11:20,099 --> 00:11:15,609
reflecting a lot more so our planet

240
00:11:22,499 --> 00:11:20,109
should be cooler make sense and if we're

241
00:11:24,989 --> 00:11:22,509
using an earth model from your service o

242
00:11:27,479 --> 00:11:24,999
videos we use the Sun we should get a

243
00:11:28,769 --> 00:11:27,489
same surface temperature as we did for

244
00:11:33,659 --> 00:11:28,779
the flat because that's how the flat

245
00:11:36,439 --> 00:11:33,669
model was chosen so we expect for

246
00:11:41,429 --> 00:11:36,449
something like this albedo we expect

247
00:11:46,529 --> 00:11:41,439
cooler stars to be hotter and hotter

248
00:11:48,960 --> 00:11:46,539
stars bluer stars to be colder and

249
00:11:51,509 --> 00:11:48,970
that's exactly what we see when we

250
00:11:53,369 --> 00:11:51,519
change the models to accept this

251
00:11:57,569 --> 00:11:53,379
wavelength dependent surface that we

252
00:12:00,449 --> 00:11:57,579
don't so here I have this is temperature

253
00:12:04,049 --> 00:12:00,459
deviation from between the flat model

254
00:12:07,319 --> 00:12:04,059
and the wavelength dependent model this

255
00:12:10,109 --> 00:12:07,329
is a surface temperature deviation as

256
00:12:12,629 --> 00:12:10,119
you can see for M stars these cooler

257
00:12:15,689 --> 00:12:12,639
stars the surface temperatures are

258
00:12:17,369 --> 00:12:15,699
hotter and for the f stars the hotter

259
00:12:22,309 --> 00:12:17,379
stars the surface temperature is cooler

260
00:12:25,199 --> 00:12:22,319
this is so this is using the earth model

261
00:12:30,899 --> 00:12:25,209
comparing it to the flat so we have

262
00:12:34,199 --> 00:12:30,909
hotter cooler and the Sun the 0.3 albedo

263
00:12:35,579 --> 00:12:34,209

that you saw here that's has been around

264
00:12:38,219 --> 00:12:35,589
for a while and that's been calibrated

265
00:12:41,009 --> 00:12:38,229
to give you the same surface temperature

266
00:12:44,189 --> 00:12:41,019
as what the earth now if you had used a

267
00:12:46,829 --> 00:12:44,199
really accurate earth model so this is

268
00:12:50,640 --> 00:12:46,839
pretty big this is you know this is

269
00:12:52,800 --> 00:12:50,650
changing how you would define sort of

270
00:12:53,390 --> 00:12:52,810
if you're using wavelength dependent up

271
00:12:55,890 --> 00:12:53,400
you go

272
00:12:57,840 --> 00:12:55,900
now instead of just using a flat line if

273
00:13:01,320 --> 00:12:57,850
you had something that more represented

274
00:13:03,420 --> 00:13:01,330
what the surface actually looks like so

275
00:13:07,110 --> 00:13:03,430
what does that mean for our planet

276
00:13:09,810 --> 00:13:07,120
JC 13q it's got so many neighbors around

277
00:13:11,940 --> 00:13:09,820
and I was thinking someone is someone's

278
00:13:13,560 --> 00:13:11,950
gonna pick a really like late letter

279
00:13:14,730 --> 00:13:13,570
we're just gonna have a lot of planets

280
00:13:16,590 --> 00:13:14,740
in this system so there's probably

281
00:13:18,600 --> 00:13:16,600
multiple there's even multiple planets

282
00:13:23,190 --> 00:13:18,610
in the habitable zone for this so what

283
00:13:26,360 --> 00:13:23,200
is this mean we don't know what the

284
00:13:29,580 --> 00:13:26,370
surface is going to be for this planet

285
00:13:31,890 --> 00:13:29,590
we have an idea of what happens surface

286
00:13:34,500 --> 00:13:31,900
might look like so we could use an earth

287
00:13:37,080 --> 00:13:34,510
model but we can also look at how this

288
00:13:39,780 --> 00:13:37,090

line changes for different types of

289
00:13:41,700 --> 00:13:39,790
services maybe there's more ocean

290
00:13:43,110 --> 00:13:41,710
there's less ocean maybe there's more

291
00:13:45,990 --> 00:13:43,120
vegetation maybe there's less of

292
00:13:49,140 --> 00:13:46,000
education deserts stuff like that so we

293
00:13:51,780 --> 00:13:49,150
can sort of look at the different

294
00:13:54,540 --> 00:13:51,790
spectra that are around us use those as

295
00:13:57,480 --> 00:13:54,550
surface albedo and see how they would

296
00:14:01,560 --> 00:13:57,490
change the habitability of a planet

297
00:14:04,350 --> 00:14:01,570
using this new method internet'll so

298
00:14:06,990 --> 00:14:04,360
I'll just leave some ring up here thank

299
00:14:11,430 --> 00:14:07,000
you thank you to my discovery team for

300
00:14:22,720 --> 00:14:14,330
[Applause]

301
00:14:28,970 --> 00:14:24,310
Hey

302
00:14:31,280 --> 00:14:28,980
very cool presentation thank you are you

303
00:14:34,220 --> 00:14:31,290
planning on using your model to any

304
00:14:36,680 --> 00:14:34,230
extra work so planet any actual

305
00:14:40,670 --> 00:14:36,690
exoplanets yes

306
00:14:43,010 --> 00:14:40,680
we are using it to model some of the

307
00:14:44,320 --> 00:14:43,020
recently found exercise and what did you

308
00:14:46,790 --> 00:14:44,330
find

309
00:14:49,130 --> 00:14:46,800
well we're sort of in the parent

310
00:14:52,010 --> 00:14:49,140
luminary stages of testing it you know

311
00:14:55,420 --> 00:14:52,020
trying out different surfaces um simple

312
00:14:57,500 --> 00:14:55,430
way we've been using it for current

313
00:15:00,860 --> 00:14:57,510

exoplanets is to use something that's

314
00:15:03,290 --> 00:15:00,870
similar to earth for now but that's

315
00:15:06,050 --> 00:15:03,300
still better than using a flat so we're

316
00:15:09,050 --> 00:15:06,060
we're taking it one step at a time yeah

317
00:15:11,090 --> 00:15:09,060
okay yeah we are we are finding that you

318
00:15:13,460 --> 00:15:11,100
know it is changing so a five degree

319
00:15:17,450 --> 00:15:13,470
difference in surface temperature can be

320
00:15:19,010 --> 00:15:17,460
pretty big for habitability um so it

321
00:15:20,900 --> 00:15:19,020
does make a pretty big difference if

322
00:15:42,540 --> 00:15:20,910
you're on dem stars which are very

323
00:15:48,330 --> 00:15:45,540
hi so I know this may be kind of a silly

324
00:15:49,920 --> 00:15:48,340
question but I'm just curious if when

325
00:15:57,720 --> 00:15:49,930
you're talking about like unserviceable

326
00:16:06,240 --> 00:15:57,730
yo are you including cloud cover and yes

327
00:16:11,070 --> 00:16:06,250
we're so if we go back to this if you've

328
00:16:13,140 --> 00:16:11,080
seen a an earth albedo that's helped me

329
00:16:17,420 --> 00:16:13,150
know it's actually very low it would

330
00:16:20,490 --> 00:16:17,430
look something more like yes so this has

331
00:16:23,490 --> 00:16:20,500
clouds incorporated into its albedo to

332
00:16:27,120 --> 00:16:23,500
get it to match a surface temperature

333
00:16:31,620 --> 00:16:27,130
that is the same as what we find for so

334
00:16:33,600 --> 00:16:31,630
we use a cloud coverage of approximately

335
00:16:35,970 --> 00:16:33,610
what we see today around like 50 percent

336
00:16:37,620 --> 00:16:35,980
cloud coverage and if we do that it

337
00:16:41,040 --> 00:16:37,630
actually gives us the same surface

338
00:16:44,130 --> 00:16:41,050

temperature which was a nice check but

339
00:16:48,030 --> 00:16:44,140
it is still not it's not like a cloud

340
00:16:49,980 --> 00:16:48,040
layer in the model there is work on

341
00:16:52,740 --> 00:16:49,990
incorporating those it's a very

342
00:16:54,360 --> 00:16:52,750
difficult problem so there isn't a super

343
00:16:57,780 --> 00:16:54,370
good solution yet on how to incorporate

344
00:17:07,750 --> 00:16:57,790
it into a 1d model but it's being worked

345
00:17:13,510 --> 00:17:09,970
um on your slide where you are showing

346
00:17:18,400 --> 00:17:13,520
the different filters it looked like you

347
00:17:20,439 --> 00:17:18,410
had gas ice and rocky does that mean

348
00:17:22,840 --> 00:17:20,449
that you are not taking into account

349
00:17:26,159 --> 00:17:22,850
water world's or are they considered

350
00:17:28,690 --> 00:17:26,169
part of ice so these are just the

351
00:17:30,100 --> 00:17:28,700
planets in our own solar system there

352
00:17:32,260 --> 00:17:30,110
are objects in our own solar system ice

353
00:17:34,299 --> 00:17:32,270
there are some moons here there's a lot

354
00:17:36,760 --> 00:17:34,309
more dots than 19 because there's some

355
00:17:39,580 --> 00:17:36,770
multiple observations you know this is

356
00:17:43,210 --> 00:17:39,590
like a Neptune or something like this

357
00:17:44,590 --> 00:17:43,220
cluster so yeah each one of these is one

358
00:17:49,390 --> 00:17:44,600
of the objects in our solar system that

359
00:17:54,220 --> 00:17:49,400
I had on this but if you did have it so

360
00:17:58,570 --> 00:17:54,230
earth is pretty much it's very close to

361
00:18:01,450 --> 00:17:58,580
a water world and we put it in the rocky

362
00:18:05,850 --> 00:18:01,460
group and it it matches up which is

363
00:18:09,190 --> 00:18:05,860

interesting because water and these

364
00:18:11,980 --> 00:18:09,200
wavelength ranges looks very close to

365
00:18:14,200 --> 00:18:11,990
rock it's actually very it's just very

366
00:18:16,510 --> 00:18:14,210
dark it just absorbs everything so

367
00:18:18,370 --> 00:18:16,520
that's a lot of what these rocks

368
00:18:21,070 --> 00:18:18,380
actually look like so if that's an

369
00:18:23,020 --> 00:18:21,080
interesting question to disentangle if

370
00:18:25,060 --> 00:18:23,030
you had just these to work with how can

371
00:18:32,420 --> 00:18:25,070
you distinguish between a water world