AbSciCon 2022

A Path to Thriving on the Earth & Other Planets

Dr. Aomawa Shields

1
00:00:05,269 --> 00:00:01,990
so without further ado

2
00:00:09,830 --> 00:00:05,279
i am very honored today uh to introduce

3
00:00:13,030 --> 00:00:09,840
our thursday morning keynote speaker

4
00:00:15,190 --> 00:00:13,040
who is professor aomawa shields

5
00:00:18,790 --> 00:00:15,200
associate professor of physics and

6
00:00:21,590 --> 00:00:18,800
astronomy at uc irvine and an expert on

7
00:00:24,070 --> 00:00:21,600
the habitability of earth-sized planets

8
00:00:26,550 --> 00:00:24,080
orbiting low-mass stars

9
00:00:28,550 --> 00:00:26,560
dr shields holds a bachelor of science

10
00:00:30,630 --> 00:00:28,560
in earth atmospheric and planetary

11
00:00:33,190 --> 00:00:30,640
sciences from mit

12
00:00:37,030 --> 00:00:33,200
a master of fine arts and acting from

13
00:00:39,270 --> 00:00:37,040

ucla and a phd in astronomy and

14
00:00:40,709 --> 00:00:39,280
astrobiology from the university of

15
00:00:44,229 --> 00:00:40,719
washington

16
00:00:47,110 --> 00:00:44,239
she was an nsf postdoctoral fellow and a

17
00:00:48,389 --> 00:00:47,120
uc president's postdoctoral program

18
00:00:50,470 --> 00:00:48,399
fellow

19
00:00:52,389 --> 00:00:50,480
at the harvard smithsonian center for

20
00:00:55,430 --> 00:00:52,399
astrophysics

21
00:00:57,189 --> 00:00:55,440
and ucla prior to joining the faculty at

22
00:01:00,869 --> 00:00:57,199
uc irvine

23
00:01:03,990 --> 00:01:00,879
her expertise is astronomy and acting

24
00:01:06,789 --> 00:01:04,000
led her to co-host a tv show wired

25
00:01:09,910 --> 00:01:06,799
science and to found

26
00:01:12,789 --> 00:01:09,920
rising star girls a outreach program

27
00:01:15,670 --> 00:01:12,799
that combines theater writing and visual

28
00:01:17,190 --> 00:01:15,680
arts with astronomy to encourage girls

29
00:01:19,270 --> 00:01:17,200
from all different backgrounds and

30
00:01:20,630 --> 00:01:19,280
colors to explore and discover the

31
00:01:23,109 --> 00:01:20,640
universe

32
00:01:26,630 --> 00:01:23,119
a testament to her science communication

33
00:01:29,270 --> 00:01:26,640
skills her 2015 ted talk how will find

34
00:01:31,830 --> 00:01:29,280
life on other planets has been viewed

35
00:01:33,590 --> 00:01:31,840
close to 2 million times

36
00:01:35,510 --> 00:01:33,600
professor shields research group

37
00:01:37,429 --> 00:01:35,520
combines climate models with

38
00:01:39,510 --> 00:01:37,439

observational data

39
00:01:41,109 --> 00:01:39,520
to predict the climate and habitability

40
00:01:43,270 --> 00:01:41,119
of exoplanets

41
00:01:46,149 --> 00:01:43,280
her research is supported by an nsf

42
00:01:48,389 --> 00:01:46,159
career award and nasa

43
00:01:51,350 --> 00:01:48,399
nasa habitable worlds and finest

44
00:01:53,990 --> 00:01:51,360
programs her memoir life on other

45
00:01:58,230 --> 00:01:54,000
planets will be published by viking

46
00:02:00,709 --> 00:01:58,240
penguin random house in 2023 next year

47
00:02:03,510 --> 00:02:00,719
and today she will be speaking about a

48
00:02:06,389 --> 00:02:03,520
path to thriving on the earth and other

49
00:02:08,140 --> 00:02:06,399
planets please join me in a warm welcome

50
00:02:11,830 --> 00:02:08,150
to professor shields

51
00:02:14,470 --> 00:02:11,840
[Applause]

52
00:02:18,710 --> 00:02:15,670
i'm here

53
00:02:21,190 --> 00:02:18,720
it's wonderful to be here it's 5

54
00:02:23,030 --> 00:02:21,200
30 where i am

55
00:02:24,790 --> 00:02:23,040
8 30 where you are

56
00:02:27,910 --> 00:02:24,800
and i want to thank all of you for

57
00:02:29,670 --> 00:02:27,920
getting up to be with me today um i know

58
00:02:31,589 --> 00:02:29,680
i'm not in the room physically with you

59
00:02:33,830 --> 00:02:31,599
but my hope is that

60
00:02:35,350 --> 00:02:33,840
during this talk it will feel almost as

61
00:02:50,710 --> 00:02:35,360
if i am

62
00:02:50,720 --> 00:02:53,350
okay

63
00:02:56,869 --> 00:02:55,270

so i'm going to

64
00:02:59,030 --> 00:02:56,879
cover the most important part of this

65
00:03:01,430 --> 00:02:59,040
talk right off the bat and that's how to

66
00:03:03,110 --> 00:03:01,440
pronounce my name

67
00:03:04,470 --> 00:03:03,120
it's pronounced

68
00:03:07,509 --> 00:03:04,480
omaha

69
00:03:09,910 --> 00:03:07,519
and the advanced version of that is

70
00:03:12,550 --> 00:03:09,920
with no glottal stop which means you're

71
00:03:14,309 --> 00:03:12,560
not stopping the floor the flow of air

72
00:03:18,229 --> 00:03:14,319
at the back of your throat

73
00:03:21,350 --> 00:03:18,239
it's nice and fluid oh moah

74
00:03:23,670 --> 00:03:21,360
and my parents are musicians they made

75
00:03:27,670 --> 00:03:23,680
my name up out of vowel sounds

76
00:03:29,990 --> 00:03:27,680
so we talk a lot about the probability

77
00:03:32,710 --> 00:03:30,000
of our planet being the only planet in

78
00:03:35,990 --> 00:03:32,720
the universe where life exists versus

79
00:03:38,470 --> 00:03:36,000
not and i think i can safely say that

80
00:03:41,830 --> 00:03:38,480
with pretty high probability there's no

81
00:03:43,670 --> 00:03:41,840
one in the universe with my name

82
00:03:45,750 --> 00:03:43,680
the other thing i'd like to

83
00:03:47,670 --> 00:03:45,760
to do is something that

84
00:03:49,270 --> 00:03:47,680
you may not be used to doing at the

85
00:03:50,869 --> 00:03:49,280
beginning of talks

86
00:03:53,190 --> 00:03:50,879
or

87
00:03:56,470 --> 00:03:53,200
anywhere this is something that i

88
00:03:58,869 --> 00:03:56,480

started to do during the pandemic

89
00:04:01,030 --> 00:03:58,879
i do it at the beginning of every class

90
00:04:02,789 --> 00:04:01,040
i teach at the beginning of every group

91
00:04:04,550 --> 00:04:02,799
meeting that i lead and at the beginning

92
00:04:06,229 --> 00:04:04,560
of talks now

93
00:04:09,350 --> 00:04:06,239
many of us have been through a great

94
00:04:12,229 --> 00:04:09,360
deal over the past two years a lot of it

95
00:04:13,190 --> 00:04:12,239
good a lot of it not so good

96
00:04:16,150 --> 00:04:13,200
and

97
00:04:18,629 --> 00:04:16,160
being physically in a conference

98
00:04:20,870 --> 00:04:18,639
environment is something that hasn't

99
00:04:22,870 --> 00:04:20,880
occurred in a really long time and so

100
00:04:24,950 --> 00:04:22,880
for all of you who are there in person

101
00:04:26,790 --> 00:04:24,960
you may have had many many feelings

102
00:04:30,070 --> 00:04:26,800
throughout this week

103
00:04:32,710 --> 00:04:30,080
and it can be useful to take whenever

104
00:04:34,310 --> 00:04:32,720
possible a mindful moment and so i want

105
00:04:36,790 --> 00:04:34,320
to invite those who would like to to

106
00:04:39,430 --> 00:04:36,800
take a mindful moment together with me

107
00:04:42,390 --> 00:04:39,440
um so i invite you now to close your

108
00:04:44,870 --> 00:04:42,400
eyes

109
00:04:46,550 --> 00:04:44,880
and notice where your body is making

110
00:04:52,070 --> 00:04:46,560
contact with

111
00:04:57,670 --> 00:04:54,790
take a couple of deep breaths in through

112
00:05:09,189 --> 00:04:57,680
the nose

113
00:05:16,150 --> 00:05:10,629

and then return to your natural

114
00:05:18,629 --> 00:05:17,909
and notice what might be coming up for

115
00:05:20,550 --> 00:05:18,639
you

116
00:05:24,230 --> 00:05:20,560
right now

117
00:05:27,830 --> 00:05:25,830
are you tired at this point in the

118
00:05:31,189 --> 00:05:27,840
conference

119
00:05:34,150 --> 00:05:31,199
several days in are you ready to go home

120
00:05:37,670 --> 00:05:34,160
are you hoping that the conference lasts

121
00:05:37,680 --> 00:05:41,110
whatever those feelings are

122
00:05:41,120 --> 00:05:46,070
become aware of them without judgment

123
00:05:55,270 --> 00:05:49,189
and we can strive towards acceptance of

124
00:06:01,270 --> 00:05:59,029
and i'd like to pose the question to you

125
00:06:03,990 --> 00:06:01,280
is there anything that you have not yet

126
00:06:08,070 --> 00:06:04,000
gotten out of the conference

127
00:06:08,080 --> 00:06:11,830
and why might that be

128
00:06:11,840 --> 00:06:22,070
is there anything holding you back

129
00:06:27,110 --> 00:06:24,390
and again

130
00:06:29,830 --> 00:06:27,120
noticing whatever rises

131
00:06:33,350 --> 00:06:29,840
up into your awareness

132
00:06:38,629 --> 00:06:36,150
and then letting it go

133
00:06:40,390 --> 00:06:38,639
trusting that

134
00:06:45,029 --> 00:06:40,400
whatever has come up will be addressed

135
00:06:49,189 --> 00:06:47,430
let's take one more deep full breath

136
00:06:53,909 --> 00:06:49,199
perhaps the deepest breath we've taken

137
00:06:53,919 --> 00:06:57,830
side out through the mouth

138
00:07:03,749 --> 00:07:02,150

and gently wiggle your fingers and toes

139
00:07:08,150 --> 00:07:03,759
and when you're ready you can open your

140
00:07:11,029 --> 00:07:09,589
thank you for

141
00:07:12,950 --> 00:07:11,039
joining

142
00:07:14,950 --> 00:07:12,960
me and that for those who did and for

143
00:07:16,870 --> 00:07:14,960
those who did not thanks for staying

144
00:07:20,390 --> 00:07:16,880
quiet so that those of us who wanted to

145
00:07:24,070 --> 00:07:22,390
okay so

146
00:07:25,510 --> 00:07:24,080
we reached a milestone a couple of

147
00:07:27,670 --> 00:07:25,520
months ago

148
00:07:31,189 --> 00:07:27,680
and that milestone is

149
00:07:33,749 --> 00:07:31,199
5000 planets found orbiting stars other

150
00:07:36,230 --> 00:07:33,759
than the sun which we call extrasolar

151
00:07:38,790 --> 00:07:36,240
planets or exoplanets for short so we

152
00:07:42,950 --> 00:07:38,800
now have more than 5000 found across a

153
00:07:46,070 --> 00:07:42,960
range of different planetary regimes

154
00:07:48,710 --> 00:07:46,080
and we we of course know that our planet

155
00:07:51,670 --> 00:07:48,720
the present moment is the only planet

156
00:07:54,550 --> 00:07:51,680
that we know of where life exists

157
00:07:57,430 --> 00:07:54,560
but because of this growing number

158
00:07:59,589 --> 00:07:57,440
we've got many candidates

159
00:08:02,230 --> 00:07:59,599
many planets that we would classify as

160
00:08:04,790 --> 00:08:02,240
potentially habitable worlds

161
00:08:07,589 --> 00:08:04,800
where the conditions might exist for

162
00:08:08,710 --> 00:08:07,599
life as we know it perhaps life as we do

163
00:08:12,629 --> 00:08:08,720

not know it

164
00:08:15,110 --> 00:08:12,639
to exist and sustain itself

165
00:08:18,070 --> 00:08:15,120
we owe this growing number

166
00:08:19,749 --> 00:08:18,080
largely to nasa's kepler mission which

167
00:08:21,589 --> 00:08:19,759
stood

168
00:08:22,869 --> 00:08:21,599
peered at one particular patch of the

169
00:08:24,710 --> 00:08:22,879
sky

170
00:08:27,350 --> 00:08:24,720
towards the constellation cygnus and

171
00:08:32,469 --> 00:08:27,360
then later in its repurposed form as the

172
00:08:35,509 --> 00:08:32,479
k2 mission uh around the ecliptic plane

173
00:08:37,029 --> 00:08:35,519
and watched as planets as

174
00:08:39,110 --> 00:08:37,039
planets passed in front of their stars

175
00:08:41,269 --> 00:08:39,120
so watching for dips in the brightness

176
00:08:43,190 --> 00:08:41,279
of the stars due to planets passing in

177
00:08:46,070 --> 00:08:43,200
front of those stars

178
00:08:48,230 --> 00:08:46,080
this is the transit technique

179
00:08:50,550 --> 00:08:48,240
and now we've got kepler's successor the

180
00:08:54,550 --> 00:08:50,560
transiting exoplanet survey satellite or

181
00:08:56,550 --> 00:08:54,560
tess which is an all-sky mission and has

182
00:08:58,470 --> 00:08:56,560
already discovered over 200 planets so

183
00:09:01,190 --> 00:08:58,480
far and that number

184
00:09:03,590 --> 00:09:01,200
is of course going to keep growing

185
00:09:06,070 --> 00:09:03,600
we also saw the launch of the james webb

186
00:09:09,190 --> 00:09:06,080
space telescope at the end of last year

187
00:09:13,750 --> 00:09:09,200
and hopefully jwst will help us learn

188
00:09:20,550 --> 00:09:16,470

alongside dedicated missions on the

189
00:09:25,910 --> 00:09:23,430
and so we're at this stage where

190
00:09:28,710 --> 00:09:25,920
we're going to have we already do

191
00:09:29,590 --> 00:09:28,720
many many prospects for habitable worlds

192
00:09:31,190 --> 00:09:29,600
and

193
00:09:34,070 --> 00:09:31,200
we have to ask ourselves this question

194
00:09:37,190 --> 00:09:34,080
which which planets do we focus on

195
00:09:38,710 --> 00:09:37,200
with that telescope time that we do have

196
00:09:42,310 --> 00:09:38,720
to identify the next planet in the

197
00:09:47,269 --> 00:09:44,150
something that i

198
00:09:49,670 --> 00:09:47,279
became interested in early on is how the

199
00:09:52,389 --> 00:09:49,680
light from a star the incoming stellar

200
00:09:54,230 --> 00:09:52,399
radiation or the installation as i call

201
00:09:56,710 --> 00:09:54,240
it for short interacting with the

202
00:10:00,150 --> 00:09:56,720
planet's atmosphere and surface could

203
00:10:02,870 --> 00:10:00,160
influence a planet's habitability

204
00:10:04,870 --> 00:10:02,880
and i started with water ice which i

205
00:10:07,829 --> 00:10:04,880
discovered as a grad student had this

206
00:10:10,230 --> 00:10:07,839
really really cool property in that

207
00:10:12,710 --> 00:10:10,240
water ice absorbs longer redder

208
00:10:15,030 --> 00:10:12,720
wavelength light and reflects shorter

209
00:10:18,389 --> 00:10:15,040
bluer light and those of you who are at

210
00:10:21,750 --> 00:10:18,399
appsicon in 2012 may have remembered my

211
00:10:23,910 --> 00:10:21,760
fame lab talk where i basically

212
00:10:25,829 --> 00:10:23,920
became different characters for the ice

213
00:10:28,069 --> 00:10:25,839

um according to the the wavelengths i

214
00:10:30,389 --> 00:10:28,079
was talking about and that was a lot of

215
00:10:32,550 --> 00:10:30,399
fun and that was really the springboard

216
00:10:35,350 --> 00:10:32,560
for much of my dissertation work

217
00:10:37,750 --> 00:10:35,360
and i'll talk more about that later

218
00:10:40,550 --> 00:10:37,760
this is why this iceberg looks so blue

219
00:10:42,470 --> 00:10:40,560
the red the redder light makes it gets

220
00:10:44,069 --> 00:10:42,480
absorbed all the way on the way down to

221
00:10:45,990 --> 00:10:44,079
the ice and it's only the blue light

222
00:10:47,829 --> 00:10:46,000
that makes it all the way to the bottom

223
00:10:51,190 --> 00:10:47,839
to be reflected back up to our eyes and

224
00:10:52,310 --> 00:10:51,200
we see a blue iceberg

225
00:10:53,910 --> 00:10:52,320
so

226
00:10:57,269 --> 00:10:53,920
one of the ways that i explored this

227
00:11:00,550 --> 00:10:57,279
phenomenon is using 3d global climate

228
00:11:03,590 --> 00:11:00,560
models or gcms for short

229
00:11:05,190 --> 00:11:03,600
gcms have long been used to predict

230
00:11:06,550 --> 00:11:05,200
climate and weather patterns on the

231
00:11:09,030 --> 00:11:06,560
earth

232
00:11:09,990 --> 00:11:09,040
they have been used and continue to be

233
00:11:11,750 --> 00:11:10,000
used

234
00:11:13,910 --> 00:11:11,760
to forecast

235
00:11:17,509 --> 00:11:13,920
anthropogenic carbon dioxide induced

236
00:11:19,590 --> 00:11:17,519
climate change into the 2100s

237
00:11:22,069 --> 00:11:19,600
and then there's a growing subset of us

238
00:11:23,829 --> 00:11:22,079

who are using these gcms to predict

239
00:11:26,069 --> 00:11:23,839
climate and weather patterns on

240
00:11:26,829 --> 00:11:26,079
exoplanets

241
00:11:28,550 --> 00:11:26,839
so

242
00:11:30,949 --> 00:11:28,560
gcms

243
00:11:33,350 --> 00:11:30,959
solve four

244
00:11:35,509 --> 00:11:33,360
eulerian equations of motion so the

245
00:11:38,630 --> 00:11:35,519
conservation of momentum

246
00:11:40,230 --> 00:11:38,640
mass continuity conservation of energy

247
00:11:41,670 --> 00:11:40,240
and the equation of state for the

248
00:11:42,630 --> 00:11:41,680
atmosphere

249
00:11:48,230 --> 00:11:42,640
so

250
00:11:50,870 --> 00:11:48,240
apply two key assumptions

251
00:11:52,629 --> 00:11:50,880
and one is that the effects of changes

252
00:11:54,949 --> 00:11:52,639
in the vertical density on the mass

253
00:11:56,550 --> 00:11:54,959
balance and the continuity equation and

254
00:11:58,790 --> 00:11:56,560
the frictional force and the momentum

255
00:12:01,269 --> 00:11:58,800
equation are negligible and we call this

256
00:12:03,670 --> 00:12:01,279
the quasi-business approximation and

257
00:12:06,230 --> 00:12:03,680
what this does is it filters out sound

258
00:12:09,670 --> 00:12:06,240
waves in the atmosphere which change on

259
00:12:11,829 --> 00:12:09,680
time scales much smaller like seconds

260
00:12:14,069 --> 00:12:11,839
than the typical gcm time scale which is

261
00:12:15,910 --> 00:12:14,079
on the order of 15 minutes

262
00:12:17,750 --> 00:12:15,920
so that's assumption number one the

263
00:12:19,350 --> 00:12:17,760

second assumption is that the horizontal

264
00:12:21,670 --> 00:12:19,360
scale of motions

265
00:12:23,430 --> 00:12:21,680
is much larger than the vertical scale

266
00:12:24,790 --> 00:12:23,440
of motion and this is a reasonable

267
00:12:25,990 --> 00:12:24,800
approximation

268
00:12:28,069 --> 00:12:26,000
given that we're talking about

269
00:12:30,629 --> 00:12:28,079
simulating the climates of earth of

270
00:12:33,670 --> 00:12:30,639
other earths potentially other earths

271
00:12:35,990 --> 00:12:33,680
and in this case the vertical the height

272
00:12:38,389 --> 00:12:36,000
of the vertical layer the vertical fluid

273
00:12:41,110 --> 00:12:38,399
layer the atmosphere is much smaller

274
00:12:43,910 --> 00:12:41,120
than the radius of the planet

275
00:12:46,949 --> 00:12:43,920
so this allows us to then

276
00:12:48,550 --> 00:12:46,959
uh ignore changes in gravitational

277
00:12:50,150 --> 00:12:48,560
acceleration in the vertical direction

278
00:12:54,710 --> 00:12:50,160
and then we can apply the hydrostatic

279
00:12:59,269 --> 00:12:55,990
so

280
00:13:01,990 --> 00:12:59,279
model allows us

281
00:13:03,350 --> 00:13:02,000
by changing the inputs

282
00:13:05,269 --> 00:13:03,360
as opposed to

283
00:13:07,430 --> 00:13:05,279
originally these these models were

284
00:13:09,829 --> 00:13:07,440
hard-coded for the earth we can now

285
00:13:12,949 --> 00:13:09,839
change different aspects of in the model

286
00:13:15,829 --> 00:13:12,959
inputs the stellar spectrum the

287
00:13:17,910 --> 00:13:15,839
radius of the planet if we want the uh

288
00:13:19,670 --> 00:13:17,920

gravitational acceleration the

289
00:13:21,750 --> 00:13:19,680
atmospheric composition the obliquity

290
00:13:23,829 --> 00:13:21,760
the eccentricity and

291
00:13:27,269 --> 00:13:23,839
we have a different planet around a

292
00:13:30,470 --> 00:13:28,069
so

293
00:13:31,430 --> 00:13:30,480
early on in my career i was interested

294
00:13:33,350 --> 00:13:31,440
in how

295
00:13:35,910 --> 00:13:33,360
this installation

296
00:13:37,590 --> 00:13:35,920
from different types of stars and

297
00:13:39,509 --> 00:13:37,600
interacting with the planets atmosphere

298
00:13:42,550 --> 00:13:39,519
and surface might influence a planet's

299
00:13:44,310 --> 00:13:42,560
ability to be susceptible to these

300
00:13:47,030 --> 00:13:44,320
globally ice covered or so-called

301
00:13:49,030 --> 00:13:47,040
snowball states and whether

302
00:13:50,629 --> 00:13:49,040
if they got into snowball states they

303
00:13:52,470 --> 00:13:50,639
could get out of them and how their host

304
00:13:53,670 --> 00:13:52,480
star spectrum would influence that

305
00:13:55,590 --> 00:13:53,680
process

306
00:13:57,990 --> 00:13:55,600
what we found was that

307
00:13:59,189 --> 00:13:58,000
when we went on to continue this work

308
00:14:01,750 --> 00:13:59,199
later on

309
00:14:05,189 --> 00:14:01,760
and early on when i was a postdoc

310
00:14:07,030 --> 00:14:05,199
looking across multiple climate regimes

311
00:14:08,790 --> 00:14:07,040
is that so

312
00:14:10,870 --> 00:14:08,800
i'm going to define a climate term

313
00:14:12,710 --> 00:14:10,880

called hysteresis so typically in the

314
00:14:13,990 --> 00:14:12,720
gcms we start off with our planets

315
00:14:16,470 --> 00:14:14,000
either in

316
00:14:18,629 --> 00:14:16,480
warm start conditions we call that

317
00:14:21,670 --> 00:14:18,639
similar to modern day earth and then we

318
00:14:24,710 --> 00:14:21,680
dial down the installation from the star

319
00:14:27,269 --> 00:14:24,720
and once the planet's in a snowball we

320
00:14:29,350 --> 00:14:27,279
start in cold start dial up and the

321
00:14:31,990 --> 00:14:29,360
physical lag and response once you

322
00:14:34,069 --> 00:14:32,000
reverse the conditions is a measure of

323
00:14:35,269 --> 00:14:34,079
the climate hysteresis

324
00:14:37,430 --> 00:14:35,279
and the

325
00:14:40,550 --> 00:14:37,440
smaller this hysteresis the smaller

326
00:14:41,910 --> 00:14:40,560
these lines are essentially

327
00:14:44,550 --> 00:14:41,920
to each other

328
00:14:46,470 --> 00:14:44,560
the more stable the climate is

329
00:14:48,470 --> 00:14:46,480
and so what we found what we confirmed

330
00:14:50,470 --> 00:14:48,480
later on when we looked across multiple

331
00:14:51,910 --> 00:14:50,480
climate regimes from snowball up through

332
00:14:54,790 --> 00:14:51,920
moist greenhouse

333
00:14:57,269 --> 00:14:54,800
is that that smaller hysteresis for

334
00:14:59,430 --> 00:14:57,279
planets orbiting cooler smaller stars

335
00:15:02,550 --> 00:14:59,440
that trend continued across different

336
00:15:03,350 --> 00:15:02,560
climate regimes we had found earlier on

337
00:15:05,670 --> 00:15:03,360
that

338
00:15:08,389 --> 00:15:05,680

m dwarf planets planets are orbiting

339
00:15:10,230 --> 00:15:08,399
cooler smaller redder stars were harder

340
00:15:12,310 --> 00:15:10,240
to freeze and easier to thaw out of

341
00:15:14,870 --> 00:15:12,320
snowball states we see this climate

342
00:15:17,110 --> 00:15:14,880
trend continuing across these climate

343
00:15:19,110 --> 00:15:17,120
regimes the solar deglaciation or

344
00:15:20,310 --> 00:15:19,120
stellar deglaciation being far more

345
00:15:23,030 --> 00:15:20,320
effective

346
00:15:25,509 --> 00:15:23,040
for planets orbiting cooler stars and

347
00:15:28,150 --> 00:15:25,519
that's due to this lower albedo ice

348
00:15:31,110 --> 00:15:28,160
which absorbs a lot of the incident near

349
00:15:33,670 --> 00:15:31,120
ir radiation from cooler redder stars

350
00:15:35,990 --> 00:15:33,680
and also co2 and water vapor absorbing

351
00:15:38,550 --> 00:15:36,000
strongly in the atmosphere also that

352
00:15:40,310 --> 00:15:38,560
near ir radiation reducing hadley

353
00:15:42,949 --> 00:15:40,320
circulation

354
00:15:45,430 --> 00:15:42,959
that usually transports energy

355
00:15:47,269 --> 00:15:45,440
from the equator to the poles allowing

356
00:15:50,310 --> 00:15:47,279
planets to thaw out more easily from

357
00:15:55,430 --> 00:15:52,470
but of course planets can have surface

358
00:15:56,629 --> 00:15:55,440
compositions other than ocean

359
00:15:58,550 --> 00:15:56,639
in fact

360
00:15:59,590 --> 00:15:58,560
this is a little

361
00:16:01,829 --> 00:15:59,600
small range of the different

362
00:16:04,069 --> 00:16:01,839
compositions we might expect to see

363
00:16:06,550 --> 00:16:04,079

on planetary surfaces of course we can

364
00:16:09,030 --> 00:16:06,560
have different grain sizes of ice up

365
00:16:12,230 --> 00:16:09,040
here you're seeing one of the coarsest

366
00:16:14,310 --> 00:16:12,240
grain types of ice blue marine ice which

367
00:16:15,990 --> 00:16:14,320
has very few cracks in it hence the

368
00:16:17,829 --> 00:16:16,000
reason why you're able to see that blue

369
00:16:20,310 --> 00:16:17,839
color that blue

370
00:16:22,230 --> 00:16:20,320
light reflecting back up to your eyes

371
00:16:24,150 --> 00:16:22,240
and then the finest grain type of ice

372
00:16:25,590 --> 00:16:24,160
which is snow lots of scattering

373
00:16:27,269 --> 00:16:25,600
happening

374
00:16:30,870 --> 00:16:27,279
we of course could have

375
00:16:32,949 --> 00:16:30,880
ice with salts in it hydro halite

376
00:16:35,910 --> 00:16:32,959
sodium chloride precipitating up through

377
00:16:37,990 --> 00:16:35,920
the ice which as i'll show you can be

378
00:16:39,910 --> 00:16:38,000
even more reflective than snow at

379
00:16:42,389 --> 00:16:39,920
certain wavelengths

380
00:16:44,710 --> 00:16:42,399
we could have all sorts of land surface

381
00:16:48,550 --> 00:16:44,720
compositions on a planet's surface and

382
00:16:51,590 --> 00:16:48,560
so as i transitioned and into a faculty

383
00:16:54,389 --> 00:16:51,600
career i i became interested in

384
00:16:55,910 --> 00:16:54,399
kind of taking this idea of surface

385
00:16:58,790 --> 00:16:55,920
interacting with

386
00:17:00,629 --> 00:16:58,800
with starlight um to different avenues

387
00:17:02,949 --> 00:17:00,639
so different surface compositions really

388
00:17:05,189 --> 00:17:02,959

trying to get as accurate understanding

389
00:17:07,429 --> 00:17:05,199
of of the the scale of different

390
00:17:09,990 --> 00:17:07,439
surfaces we could expect on on planets

391
00:17:14,150 --> 00:17:10,000
and how that surface composition could

392
00:17:18,309 --> 00:17:15,829
and the take-home point really here is

393
00:17:20,789 --> 00:17:18,319
that the surface matters what is on the

394
00:17:23,510 --> 00:17:20,799
surface of a planet matters even with

395
00:17:27,350 --> 00:17:23,520
a relatively thick atmosphere the

396
00:17:32,710 --> 00:17:29,270
there are many ways to look for life on

397
00:17:34,390 --> 00:17:32,720
other planets this is one and this is

398
00:17:37,510 --> 00:17:34,400
another and this is the way that i do

399
00:17:39,909 --> 00:17:37,520
this when i've got observational data

400
00:17:42,549 --> 00:17:39,919
for particular planets i use that and

401
00:17:43,350 --> 00:17:42,559
input that into the climate model

402
00:17:45,669 --> 00:17:43,360
and

403
00:17:47,750 --> 00:17:45,679
of course what i don't have about a

404
00:17:50,310 --> 00:17:47,760
planetary system i

405
00:17:52,390 --> 00:17:50,320
fill in or do parameter sweeps or you

406
00:17:54,230 --> 00:17:52,400
know fill in the gaps using computer

407
00:17:56,310 --> 00:17:54,240
models so we and that two-tiered

408
00:17:58,310 --> 00:17:56,320
approach allows me to understand and

409
00:18:01,510 --> 00:17:58,320
allows our group to understand

410
00:18:04,230 --> 00:18:01,520
the true influence of different factors

411
00:18:07,510 --> 00:18:04,240
on planetary climate and habitability

412
00:18:09,190 --> 00:18:07,520
so we typically start with a planet that

413
00:18:11,270 --> 00:18:09,200

when we know when we have observational

414
00:18:12,710 --> 00:18:11,280
data for this planet that we know it's

415
00:18:15,190 --> 00:18:12,720
in the habitable zone this is that

416
00:18:17,990 --> 00:18:15,200
region around a star where a planet with

417
00:18:20,310 --> 00:18:18,000
an earth-like composition could keep

418
00:18:22,310 --> 00:18:20,320
water liquid on the surface

419
00:18:25,110 --> 00:18:22,320
right too close

420
00:18:27,270 --> 00:18:25,120
end to the star and the oceans would

421
00:18:29,510 --> 00:18:27,280
boil away in a runaway greenhouse state

422
00:18:32,070 --> 00:18:29,520
too far away and you reach this point

423
00:18:35,669 --> 00:18:32,080
called the maximum co2 greenhouse where

424
00:18:38,070 --> 00:18:35,679
the warming effects of co2 due to a

425
00:18:41,350 --> 00:18:38,080
carbonate silicate cycle become far less

426
00:18:43,029 --> 00:18:41,360
efficient and no longer able to sustain

427
00:18:44,470 --> 00:18:43,039
temperatures warm enough for surface

428
00:18:45,990 --> 00:18:44,480
liquid water

429
00:18:47,909 --> 00:18:46,000
so as you notice

430
00:18:49,669 --> 00:18:47,919
the habitable zone much farther away

431
00:18:51,029 --> 00:18:49,679
from a hotter brighter star than a

432
00:18:53,669 --> 00:18:51,039
cooler

433
00:18:56,470 --> 00:18:53,679
dimmer star

434
00:18:58,630 --> 00:18:56,480
but unfortunately it's not as easy as

435
00:19:00,070 --> 00:18:58,640
just choosing a planet that orbits its

436
00:19:02,630 --> 00:19:00,080
star at a particular distance and

437
00:19:05,029 --> 00:19:02,640
deeming that planet habitable

438
00:19:06,950 --> 00:19:05,039

there are a lot of factors that

439
00:19:10,310 --> 00:19:06,960
influence the long-term presence of

440
00:19:12,070 --> 00:19:10,320
liquid water on a planetary surface

441
00:19:16,150 --> 00:19:12,080
and it can be overwhelming to think

442
00:19:19,990 --> 00:19:17,909
so

443
00:19:21,190 --> 00:19:20,000
much of what my focus has been over the

444
00:19:23,750 --> 00:19:21,200
years is

445
00:19:25,830 --> 00:19:23,760
m dwarf planets planets orbiting these

446
00:19:28,310 --> 00:19:25,840
small cool red stars

447
00:19:30,230 --> 00:19:28,320
and there's a reason for that m dwarfs

448
00:19:33,270 --> 00:19:30,240
are the most numerous types of stars in

449
00:19:36,230 --> 00:19:33,280
the galaxy 75 of all stars in the milky

450
00:19:38,150 --> 00:19:36,240
way are m dwarfs so they offer that best

451
00:19:40,230 --> 00:19:38,160
probability of finding habitable planets

452
00:19:42,549 --> 00:19:40,240
through sheer numbers alone it's easier

453
00:19:44,310 --> 00:19:42,559
to detect planets around em dwarfs with

454
00:19:46,950 --> 00:19:44,320
existing techniques

455
00:19:48,549 --> 00:19:46,960
they're also extremely long lived right

456
00:19:51,590 --> 00:19:48,559
no m dwarfs

457
00:19:53,830 --> 00:19:51,600
have ever died their their longevity

458
00:19:56,230 --> 00:19:53,840
their lifetimes are longer than the

459
00:19:57,270 --> 00:19:56,240
current age of the universe so this

460
00:19:59,430 --> 00:19:57,280
would offer

461
00:20:03,110 --> 00:19:59,440
lengthy time scales for both planetary

462
00:20:05,909 --> 00:20:03,909
so

463
00:20:09,029 --> 00:20:05,919

one of the first things i had my first

464
00:20:10,789 --> 00:20:09,039
postdoc andrew rushby work on was land

465
00:20:12,390 --> 00:20:10,799
let's put land on a surface let's not

466
00:20:14,950 --> 00:20:12,400
just assume these planets are aqua

467
00:20:15,990 --> 00:20:14,960
planets let's see how the influence of

468
00:20:17,270 --> 00:20:16,000
land

469
00:20:18,789 --> 00:20:17,280
could could govern climate

470
00:20:21,110 --> 00:20:18,799
inhabitability

471
00:20:23,270 --> 00:20:21,120
and so he started with a sort of

472
00:20:25,190 --> 00:20:23,280
representative land surface that's often

473
00:20:28,549 --> 00:20:25,200
used in climate models a kind of clay

474
00:20:30,950 --> 00:20:28,559
kaolinite surface um intermediate albedo

475
00:20:32,149 --> 00:20:30,960
or reflectivity spectrum

476
00:20:36,230 --> 00:20:32,159
and

477
00:20:37,990 --> 00:20:36,240
on a planet surface could influence its

478
00:20:39,990 --> 00:20:38,000
habitability and these were theoretical

479
00:20:41,750 --> 00:20:40,000
planets we weren't looking at actual

480
00:20:43,990 --> 00:20:41,760
observed planets just changing the

481
00:20:46,789 --> 00:20:44,000
spectrum of the star and we were doing

482
00:20:49,029 --> 00:20:46,799
this with an energy balance model or ebm

483
00:20:50,950 --> 00:20:49,039
one-dimensional

484
00:20:53,430 --> 00:20:50,960
and what we found is that so here you're

485
00:20:57,029 --> 00:20:53,440
seeing percentage of land on the x-axis

486
00:20:59,590 --> 00:20:57,039
and then global mean surface temperature

487
00:21:02,070 --> 00:20:59,600
on the y-axis and what we found is that

488
00:21:04,070 --> 00:21:02,080

the more land you've got on the planet

489
00:21:07,110 --> 00:21:04,080
because it's some wavelengths land can

490
00:21:08,470 --> 00:21:07,120
be brighter than ice

491
00:21:10,789 --> 00:21:08,480
so the more

492
00:21:15,190 --> 00:21:10,799
the more land you have on the surface

493
00:21:18,149 --> 00:21:16,710
right so

494
00:21:26,789 --> 00:21:18,159
that

495
00:21:29,270 --> 00:21:26,799
m dwarfs are still at a given land

496
00:21:31,270 --> 00:21:29,280
percentage warmer

497
00:21:33,590 --> 00:21:31,280
than planets around indoor planets or

498
00:21:36,390 --> 00:21:33,600
warmer than planets around other hotter

499
00:21:38,549 --> 00:21:36,400
brighter stars

500
00:21:41,270 --> 00:21:38,559
and that's due to this

501
00:21:44,230 --> 00:21:41,280
this ice albedo effect that where you

502
00:21:45,750 --> 00:21:44,240
have ice on the planet that ice is is a

503
00:21:48,230 --> 00:21:45,760
lower albedo it's going to absorb that

504
00:21:49,830 --> 00:21:48,240
near ir radiation and then contribute to

505
00:21:53,830 --> 00:21:49,840
the increased warming on an m dwarf

506
00:21:56,870 --> 00:21:53,840
planet compared to to other planets

507
00:21:59,029 --> 00:21:56,880
so yes we we had this kind of early look

508
00:22:01,750 --> 00:21:59,039
at what could happen

509
00:22:03,990 --> 00:22:01,760
when you put land on a planet surface

510
00:22:06,549 --> 00:22:04,000
but of course land could be

511
00:22:09,669 --> 00:22:06,559
many different types beyond clay or

512
00:22:12,230 --> 00:22:09,679
keolinite and so the next step andrew

513
00:22:13,990 --> 00:22:12,240

took was looking at a specific planetary

514
00:22:16,149 --> 00:22:14,000
system trappist-1 which is a very

515
00:22:17,669 --> 00:22:16,159
popular system because it's extremely

516
00:22:20,710 --> 00:22:17,679
exciting we have several potentially

517
00:22:22,470 --> 00:22:20,720
habitable planets within this system

518
00:22:24,549 --> 00:22:22,480
and we wanted to see what happens if you

519
00:22:27,590 --> 00:22:24,559
change the land surface composition and

520
00:22:28,789 --> 00:22:27,600
this time we went up to the 3d gcm

521
00:22:31,510 --> 00:22:28,799
and so up here you're seeing the

522
00:22:32,950 --> 00:22:31,520
spectrum of trappist-1 it's ultra cool m

523
00:22:35,430 --> 00:22:32,960
dwarf here

524
00:22:37,510 --> 00:22:35,440
alongside several other stellar spectra

525
00:22:39,110 --> 00:22:37,520
including the sun

526
00:22:40,710 --> 00:22:39,120
and on the bottom is albedo as a

527
00:22:42,789 --> 00:22:40,720
function of wavelength for different

528
00:22:44,710 --> 00:22:42,799
types of land surfaces and so you have

529
00:22:46,950 --> 00:22:44,720
something here called aridasol which is

530
00:22:48,549 --> 00:22:46,960
similar to that kaolinite and its albedo

531
00:22:50,710 --> 00:22:48,559
spectrum sort of intermediate

532
00:22:53,350 --> 00:22:50,720
representative spectrum but then we also

533
00:22:55,909 --> 00:22:53,360
have the low albedo granite

534
00:22:58,789 --> 00:22:55,919
surface type and we have a super high

535
00:23:00,789 --> 00:22:58,799
albedo calcite surface

536
00:23:03,350 --> 00:23:00,799
we also have dune sand so see how

537
00:23:04,710 --> 00:23:03,360
different these reflectivity spectra can

538
00:23:06,630 --> 00:23:04,720

get

539
00:23:08,549 --> 00:23:06,640
that in itself was interesting to us and

540
00:23:10,710 --> 00:23:08,559
we knew there was going to be some im

541
00:23:13,590 --> 00:23:10,720
impact what we found was that the

542
00:23:15,990 --> 00:23:13,600
difference in surface temperature

543
00:23:17,510 --> 00:23:16,000
across these different slant surface

544
00:23:20,710 --> 00:23:17,520
albedo spectra

545
00:23:23,990 --> 00:23:20,720
was as much as 50 degrees kelvin

546
00:23:26,230 --> 00:23:24,000
that lower albedo versus high albedo

547
00:23:28,149 --> 00:23:26,240
land surface makes a difference

548
00:23:30,549 --> 00:23:28,159
we end up seeing

549
00:23:31,830 --> 00:23:30,559
increased cross equatorial energy

550
00:23:35,190 --> 00:23:31,840
transport

551
00:23:38,470 --> 00:23:35,200
for the lowest albedo surfaces granite

552
00:23:39,430 --> 00:23:38,480
compared to calcite for trappist-1 d e

553
00:23:41,669 --> 00:23:39,440
and f

554
00:23:44,630 --> 00:23:41,679
with planet around the sun for for

555
00:23:49,190 --> 00:23:46,190
and that increased

556
00:23:51,590 --> 00:23:49,200
cross-equatorial energy transport

557
00:23:53,669 --> 00:23:51,600
allows these these surface temperatures

558
00:23:55,590 --> 00:23:53,679
to to end up being higher on the day

559
00:23:58,630 --> 00:23:55,600
sides of these planets

560
00:23:59,990 --> 00:23:58,640
trappist-1d the most likely

561
00:24:01,990 --> 00:24:00,000
to exhibit habitable surface

562
00:24:07,510 --> 00:24:02,000
temperatures with that lowest albedo

563
00:24:11,269 --> 00:24:09,590

so i'm going to move on to hydra halite

564
00:24:14,070 --> 00:24:11,279
which um i found particularly

565
00:24:15,350 --> 00:24:14,080
interesting as someone who's always

566
00:24:16,870 --> 00:24:15,360
loved and been

567
00:24:19,830 --> 00:24:16,880
intrigued by this

568
00:24:21,510 --> 00:24:19,840
bipolar nature of water ice then we put

569
00:24:24,390 --> 00:24:21,520
salts in it and you get like a whole

570
00:24:26,950 --> 00:24:24,400
different uh scenario so what you're

571
00:24:29,430 --> 00:24:26,960
looking at here is a brine pocket and on

572
00:24:31,190 --> 00:24:29,440
the left it's filled with liquid

573
00:24:34,149 --> 00:24:31,200
and then on the right

574
00:24:35,830 --> 00:24:34,159
taken 15 minutes later at minus 28

575
00:24:37,909 --> 00:24:35,840
degrees celsius

576
00:24:41,269 --> 00:24:37,919
the brine pocket you see sodium chloride

577
00:24:42,230 --> 00:24:41,279
has crystallized and filled the pocket

578
00:24:44,310 --> 00:24:42,240
um

579
00:24:47,350 --> 00:24:44,320
and and that those crystals have blocked

580
00:24:49,590 --> 00:24:47,360
the light

581
00:24:52,470 --> 00:24:49,600
so hydro halide can start to precipitate

582
00:24:54,870 --> 00:24:52,480
below minus 23 degrees celsius and at

583
00:24:58,470 --> 00:24:54,880
minus 40 degrees celsius you can have a

584
00:24:59,590 --> 00:24:58,480
crust form on top of that on top of the

585
00:25:01,350 --> 00:24:59,600
ice

586
00:25:03,350 --> 00:25:01,360
so i'm showing you again albedo or

587
00:25:05,830 --> 00:25:03,360
reflectivity as a function of wavelength

588
00:25:07,430 --> 00:25:05,840

for some of these ice surfaces that

589
00:25:09,669 --> 00:25:07,440
we've already talked about

590
00:25:12,710 --> 00:25:09,679
um ocean there for comparison and look

591
00:25:15,110 --> 00:25:12,720
at hydro halite so in the area where

592
00:25:16,310 --> 00:25:15,120
we're salt free ice and snow gets very

593
00:25:19,350 --> 00:25:16,320
absorptive

594
00:25:21,269 --> 00:25:19,360
that near-infrared hydro halite gets

595
00:25:23,029 --> 00:25:21,279
very reflective

596
00:25:25,510 --> 00:25:23,039
right in the region where m dwarfs emit

597
00:25:27,269 --> 00:25:25,520
that near ir and so

598
00:25:30,310 --> 00:25:27,279
my collaborator regina carnes

599
00:25:32,710 --> 00:25:30,320
glaciologist uh reached out to me a long

600
00:25:34,149 --> 00:25:32,720
time ago right before i uh

601
00:25:35,510 --> 00:25:34,159
was about to give birth

602
00:25:38,390 --> 00:25:35,520
and said

603
00:25:40,070 --> 00:25:38,400
do you want to write a paper on this um

604
00:25:43,750 --> 00:25:40,080
and because she looked at this from a

605
00:25:45,830 --> 00:25:43,760
standpoint of uh of snowball earth and

606
00:25:47,990 --> 00:25:45,840
how it could change the energy balance

607
00:25:50,310 --> 00:25:48,000
of snowball earth if we if we had

608
00:25:52,710 --> 00:25:50,320
included hydrohalide kind of in our

609
00:25:54,390 --> 00:25:52,720
calculations about um when it came to

610
00:25:56,149 --> 00:25:54,400
freezing and how long it would take for

611
00:25:59,110 --> 00:25:56,159
for surfaces to thaw and things like

612
00:26:02,390 --> 00:25:59,120
that but no one had applied the

613
00:26:05,029 --> 00:26:02,400

hydro halide albedo parameterization uh

614
00:26:07,269 --> 00:26:05,039
in climate simulations of exoplanets and

615
00:26:10,070 --> 00:26:07,279
so that's what we did

616
00:26:11,669 --> 00:26:10,080
we ran control cases where we didn't

617
00:26:13,190 --> 00:26:11,679
change the albedo parameterization and

618
00:26:15,029 --> 00:26:13,200
so whenever it got below freezing

619
00:26:17,350 --> 00:26:15,039
temperatures got below freezing

620
00:26:19,669 --> 00:26:17,360
the albedos for salt free water ice were

621
00:26:21,430 --> 00:26:19,679
applied and then we applied a hydro

622
00:26:24,710 --> 00:26:21,440
halite albedo parameterization for

623
00:26:26,710 --> 00:26:24,720
temperatures below the minus 23c a

624
00:26:28,149 --> 00:26:26,720
separate spectrum for when

625
00:26:30,549 --> 00:26:28,159
um when

626
00:26:32,630 --> 00:26:30,559
precipitate when hydro halite began to

627
00:26:35,350 --> 00:26:32,640
precipitate that's this cold bear ice

628
00:26:37,430 --> 00:26:35,360
spectrum it has it's cold bear ice with

629
00:26:40,070 --> 00:26:37,440
precipitated hydro halite so it's just

630
00:26:42,870 --> 00:26:40,080
starting to crystallize and then here is

631
00:26:44,549 --> 00:26:42,880
that fully formed crust

632
00:26:46,549 --> 00:26:44,559
and so

633
00:26:47,909 --> 00:26:46,559
that is what we applied at minus 40

634
00:26:52,390 --> 00:26:47,919
degrees c

635
00:26:55,590 --> 00:26:52,400
and what we found was was interesting

636
00:26:57,350 --> 00:26:55,600
at about 90 degrees that's excuse me 90

637
00:26:59,350 --> 00:26:57,360
of the modern solar constant and that

638
00:27:02,070 --> 00:26:59,360

these first planets we just gave them

639
00:27:03,830 --> 00:27:02,080
earth-like 24-hour rotation periods at

640
00:27:06,310 --> 00:27:03,840
about 90 percent of the modern solar

641
00:27:07,669 --> 00:27:06,320
constant so 90 of what earth gets from

642
00:27:10,149 --> 00:27:07,679
the sun

643
00:27:13,269 --> 00:27:10,159
the impact was negligible

644
00:27:15,190 --> 00:27:13,279
but once we got to 65 so we dialed down

645
00:27:16,630 --> 00:27:15,200
the installation to 65 percent of the

646
00:27:19,029 --> 00:27:16,640
modern solar constant and that's this

647
00:27:21,750 --> 00:27:19,039
red curve we began to see

648
00:27:24,070 --> 00:27:21,760
non-negligible effects

649
00:27:26,789 --> 00:27:24,080
and 65 percent of the modern solar

650
00:27:28,470 --> 00:27:26,799
constant at at the with the m dwarf

651
00:27:30,310 --> 00:27:28,480
spectrum that we used here was in the

652
00:27:33,350 --> 00:27:30,320
habitable zone

653
00:27:35,990 --> 00:27:33,360
so what that told us is that this

654
00:27:38,470 --> 00:27:36,000
temperatures can get cold enough

655
00:27:40,710 --> 00:27:38,480
on rapidly rotating planets

656
00:27:41,669 --> 00:27:40,720
in the habitable zone for hydro halide

657
00:27:43,110 --> 00:27:41,679
to form

658
00:27:44,789 --> 00:27:43,120
and then of course as the insulation

659
00:27:46,630 --> 00:27:44,799
goes down and you have regions in the

660
00:27:48,950 --> 00:27:46,640
tropics where there's net evaporation

661
00:27:51,510 --> 00:27:48,960
this effect is even stronger and g dwarf

662
00:27:53,269 --> 00:27:51,520
planets being colder than m dwarfs at

663
00:27:55,990 --> 00:27:53,279

equivalent stellar flux distances which

664
00:27:57,590 --> 00:27:56,000
we had found many years prior

665
00:27:58,870 --> 00:27:57,600
are just more susceptible in general to

666
00:28:00,950 --> 00:27:58,880
this effect

667
00:28:02,710 --> 00:28:00,960
but it was like habitable zone planets

668
00:28:04,630 --> 00:28:02,720
rapidly rotating

669
00:28:05,909 --> 00:28:04,640
can get cold enough for hydrohalide to

670
00:28:07,029 --> 00:28:05,919
form so

671
00:28:08,470 --> 00:28:07,039
we need to put this albedo

672
00:28:10,950 --> 00:28:08,480
parameterization into climate

673
00:28:14,870 --> 00:28:10,960
simulations on the regular otherwise

674
00:28:16,310 --> 00:28:14,880
we're missing out on a fully accurate

675
00:28:17,830 --> 00:28:16,320
representation of what the possible

676
00:28:19,590 --> 00:28:17,840
climates could be

677
00:28:21,350 --> 00:28:19,600
and then it gets even better because

678
00:28:23,350 --> 00:28:21,360
once we

679
00:28:25,909 --> 00:28:23,360
changed our rotation rate

680
00:28:27,669 --> 00:28:25,919
to a synchronously rotating

681
00:28:31,750 --> 00:28:27,679
m dwarf planet

682
00:28:34,789 --> 00:28:31,760
were even more susceptible to this

683
00:28:36,630 --> 00:28:34,799
effect here you see at 90 percent of the

684
00:28:38,950 --> 00:28:36,640
modern solar constant

685
00:28:41,430 --> 00:28:38,960
so 90 installation

686
00:28:43,669 --> 00:28:41,440
this synchronously rotating planet

687
00:28:46,149 --> 00:28:43,679
gets it you know it definitely gets

688
00:28:48,149 --> 00:28:46,159

colder on the day side

689
00:28:49,830 --> 00:28:48,159
and uh compared to rapidly rotating

690
00:28:52,230 --> 00:28:49,840
planets so they reach minimum the

691
00:28:54,789 --> 00:28:52,240
minimum surface temperatures are lower

692
00:28:57,590 --> 00:28:54,799
compared to the um on the rapidly

693
00:28:59,669 --> 00:28:57,600
rotating case and so

694
00:29:01,909 --> 00:28:59,679
habitable zone synchronous hemdorf

695
00:29:03,830 --> 00:29:01,919
planets um would definitely we want to

696
00:29:05,990 --> 00:29:03,840
apply this parameterization otherwise

697
00:29:08,470 --> 00:29:06,000
again we're we're underestimating or

698
00:29:10,230 --> 00:29:08,480
excuse me we're overestimating the

699
00:29:16,070 --> 00:29:10,240
surface temperatures that we would

700
00:29:21,110 --> 00:29:18,789
of course we wanted to also explore the

701
00:29:23,269 --> 00:29:21,120
fact that not all planets are orbiting

702
00:29:25,269 --> 00:29:23,279
their stars in circular orbits

703
00:29:27,590 --> 00:29:25,279
and our earth is orbiting in almost a

704
00:29:29,110 --> 00:29:27,600
perfect circular orbit

705
00:29:31,909 --> 00:29:29,120
but there's

706
00:29:33,830 --> 00:29:31,919
many many planets that have non-zero

707
00:29:35,430 --> 00:29:33,840
eccentricities and what could this do

708
00:29:37,750 --> 00:29:35,440
when it comes to

709
00:29:39,750 --> 00:29:37,760
freezing at appalachian

710
00:29:43,350 --> 00:29:39,760
heating up and maybe even run away

711
00:29:45,190 --> 00:29:43,360
greenhousing at periastron and how could

712
00:29:47,909 --> 00:29:45,200
the surface interaction with the

713
00:29:49,590 --> 00:29:47,919

installation um influence climate and

714
00:29:51,590 --> 00:29:49,600
habitability and so we we've explored

715
00:29:53,909 --> 00:29:51,600
this in a number of ways one of the

716
00:29:56,070 --> 00:29:53,919
first ways was actually to constrain

717
00:29:57,750 --> 00:29:56,080
fractional habitability throughout a

718
00:29:59,750 --> 00:29:57,760
planet's year as a function of its

719
00:30:00,789 --> 00:29:59,760
eccentricity and its host star spectral

720
00:30:03,590 --> 00:30:00,799
type

721
00:30:05,590 --> 00:30:03,600
and what we it's that this plot shows

722
00:30:07,430 --> 00:30:05,600
starlight and as a fraction of what

723
00:30:08,789 --> 00:30:07,440
earth gets from

724
00:30:09,750 --> 00:30:08,799
the sun

725
00:30:12,789 --> 00:30:09,760
and then

726
00:30:14,789 --> 00:30:12,799
eccentricity or also known as how

727
00:30:16,470 --> 00:30:14,799
elongated your orbit is

728
00:30:18,870 --> 00:30:16,480
on the um

729
00:30:20,070 --> 00:30:18,880
on this axis and then

730
00:30:22,230 --> 00:30:20,080
what you're seeing is fractional

731
00:30:24,630 --> 00:30:22,240
habitability so right the more yellow

732
00:30:26,870 --> 00:30:24,640
there is the the higher the fraction of

733
00:30:28,310 --> 00:30:26,880
habitability

734
00:30:31,190 --> 00:30:28,320
and

735
00:30:33,029 --> 00:30:31,200
this was exciting because what we see is

736
00:30:35,750 --> 00:30:33,039
that yes of course

737
00:30:37,110 --> 00:30:35,760
the the lower eccentricities allow

738
00:30:39,590 --> 00:30:37,120

planets to be

739
00:30:42,230 --> 00:30:39,600
habitable for a larger fraction of their

740
00:30:45,510 --> 00:30:42,240
years but even in the most

741
00:30:48,149 --> 00:30:45,520
highly elongated orbits we can still see

742
00:30:51,350 --> 00:30:48,159
habitable surface temperatures

743
00:30:54,310 --> 00:30:51,360
during an orbit and so this the

744
00:30:56,950 --> 00:30:54,320
eccentric habitable zone which was um a

745
00:30:59,029 --> 00:30:56,960
term that had been uh coined almost a

746
00:31:00,389 --> 00:30:59,039
decade ago by rory barnes and others

747
00:31:03,269 --> 00:31:00,399
they were able to show that this

748
00:31:06,070 --> 00:31:03,279
eccentric habitable zone is sensitive to

749
00:31:08,230 --> 00:31:06,080
costar spectral type

750
00:31:09,110 --> 00:31:08,240
right that the the cooler the star as

751
00:31:11,990 --> 00:31:09,120
well

752
00:31:14,549 --> 00:31:12,000
the larger the fraction of the year over

753
00:31:17,590 --> 00:31:14,559
which it's habitable

754
00:31:19,750 --> 00:31:17,600
as a function of its eccentricity

755
00:31:22,870 --> 00:31:19,760
we've also looked at

756
00:31:25,190 --> 00:31:22,880
how installation is budgeted across a

757
00:31:26,789 --> 00:31:25,200
planet's atmosphere and surface so i

758
00:31:28,470 --> 00:31:26,799
became curious

759
00:31:30,230 --> 00:31:28,480
after these sort of initial studies of

760
00:31:32,230 --> 00:31:30,240
like you know we know that

761
00:31:34,149 --> 00:31:32,240
a planet orbiting an m dwarf at an

762
00:31:35,029 --> 00:31:34,159
equivalent flux distance

763
00:31:36,789 --> 00:31:35,039

um

764
00:31:39,029 --> 00:31:36,799
to a planet orbiting a g-dwarf is just

765
00:31:40,070 --> 00:31:39,039
going to be all other things equal

766
00:31:43,509 --> 00:31:40,080
warmer

767
00:31:46,470 --> 00:31:43,519
um but i wanted to know why like

768
00:31:48,389 --> 00:31:46,480
what really was it it's not just like

769
00:31:50,230 --> 00:31:48,399
yet we know that the the surface and the

770
00:31:51,990 --> 00:31:50,240
atmosphere are playing a role but i

771
00:31:55,190 --> 00:31:52,000
really wanted to sort of see it in the

772
00:31:57,029 --> 00:31:55,200
numbers and this energy budget and

773
00:31:58,870 --> 00:31:57,039
energy budget pathways were first

774
00:32:01,110 --> 00:31:58,880
created by kevin trenberth and

775
00:32:04,230 --> 00:32:01,120
collaborators and we have this because

776
00:32:05,909 --> 00:32:04,240
of gcms in concert with satellite data

777
00:32:07,990 --> 00:32:05,919
we've gotten for the earth

778
00:32:13,269 --> 00:32:08,000
but no one had ever done it

779
00:32:18,149 --> 00:32:15,990
so again looking at installation

780
00:32:20,149 --> 00:32:18,159
global means surface temperature

781
00:32:21,669 --> 00:32:20,159
and m dwarf planet

782
00:32:24,950 --> 00:32:21,679
at a distance where it receives an

783
00:32:29,190 --> 00:32:24,960
equivalent amount of flux to a g dwarf

784
00:32:31,830 --> 00:32:29,200
and a an f dwarf planet oops

785
00:32:34,389 --> 00:32:31,840
is going to it's not going to require as

786
00:32:35,909 --> 00:32:34,399
much flux to get to that a similar

787
00:32:37,669 --> 00:32:35,919
surface temperature

788
00:32:39,350 --> 00:32:37,679

right it can get to

789
00:32:42,389 --> 00:32:39,360
that global mean surface temperature of

790
00:32:43,269 --> 00:32:42,399
288 kelvin

791
00:32:45,509 --> 00:32:43,279
at

792
00:32:48,630 --> 00:32:45,519
88 percent of the modern solar constant

793
00:32:51,110 --> 00:32:48,640
compared to 100 for the g dwarf and 108

794
00:32:52,710 --> 00:32:51,120
for the f dwarf

795
00:32:55,269 --> 00:32:52,720
and so when we made these trend birth

796
00:32:58,310 --> 00:32:55,279
diagrams

797
00:32:59,669 --> 00:32:58,320
we were able to quantify percentage-wise

798
00:33:01,590 --> 00:32:59,679
what actually is going on in the

799
00:33:03,990 --> 00:33:01,600
atmosphere and at the surface so we were

800
00:33:05,909 --> 00:33:04,000
able to look at the f dwarf planet for

801
00:33:06,870 --> 00:33:05,919
example planet around f dwarf star and

802
00:33:10,230 --> 00:33:06,880
see that

803
00:33:12,710 --> 00:33:10,240
where 29 of the incoming radiation is

804
00:33:15,750 --> 00:33:12,720
reflected by the atmosphere and 14

805
00:33:17,830 --> 00:33:15,760
absorbed 16 reflected by the surface

806
00:33:20,310 --> 00:33:17,840
when we change that spectrum that host

807
00:33:22,710 --> 00:33:20,320
star spectrum to an m dwarf

808
00:33:24,389 --> 00:33:22,720
we really see up close what's

809
00:33:27,110 --> 00:33:24,399
what's really happening that

810
00:33:29,590 --> 00:33:27,120
there's far less reflected

811
00:33:31,350 --> 00:33:29,600
by the atmosphere on the m dwarf far

812
00:33:32,870 --> 00:33:31,360
more absorbed

813
00:33:35,669 --> 00:33:32,880

by the atmosphere

814
00:33:37,269 --> 00:33:35,679
and far more absorbed at the surface far

815
00:33:43,350 --> 00:33:37,279
more of what reaches the surface

816
00:33:48,549 --> 00:33:45,669
i wish i could go on and on about the

817
00:33:51,029 --> 00:33:48,559
pros and cons of habitability on planets

818
00:33:53,029 --> 00:33:51,039
orbiting mdorf stars

819
00:33:54,549 --> 00:33:53,039
what i want to do instead is refer those

820
00:33:55,590 --> 00:33:54,559
of you who are really interested in this

821
00:33:57,350 --> 00:33:55,600
topic

822
00:33:59,509 --> 00:33:57,360
senior undergrads

823
00:34:00,870 --> 00:33:59,519
new grad students to

824
00:34:03,909 --> 00:34:00,880
go find

825
00:34:06,230 --> 00:34:03,919
our review paper that i wrote

826
00:34:08,470 --> 00:34:06,240
almost a decade ago now or no not not

827
00:34:10,629 --> 00:34:08,480
that long 2016. so

828
00:34:12,869 --> 00:34:10,639
a little over five years um with john

829
00:34:13,750 --> 00:34:12,879
johnson and sarah ballard um

830
00:34:15,990 --> 00:34:13,760
and

831
00:34:16,710 --> 00:34:16,000
it's almost time for for a new one but

832
00:34:18,710 --> 00:34:16,720
we

833
00:34:21,270 --> 00:34:18,720
have synthesized everything at the time

834
00:34:23,829 --> 00:34:21,280
that was known about m dwarf planet

835
00:34:28,470 --> 00:34:23,839
habitability from both an observational

836
00:34:33,909 --> 00:34:31,430
this habitable zone of course seeing

837
00:34:37,750 --> 00:34:33,919
that it's closer in for smaller bright

838
00:34:39,990 --> 00:34:37,760

smaller and dimmer stars has

839
00:34:41,030 --> 00:34:40,000
brought up a lot of concerns over the

840
00:34:42,389 --> 00:34:41,040
years

841
00:34:43,829 --> 00:34:42,399
about the

842
00:34:46,629 --> 00:34:43,839
possible

843
00:34:48,389 --> 00:34:46,639
habitability of planets that

844
00:34:50,869 --> 00:34:48,399
because they're so close to their stars

845
00:34:52,950 --> 00:34:50,879
undergo tidal locking and the most

846
00:34:54,389 --> 00:34:52,960
extreme case of that is the one-to-one

847
00:34:57,190 --> 00:34:54,399
spin orbit resonance known as

848
00:34:59,430 --> 00:34:57,200
synchronous rotation where the planets

849
00:35:02,310 --> 00:34:59,440
takes as long to rotate once on its axis

850
00:35:03,750 --> 00:35:02,320
as it does to orbit the star so its day

851
00:35:05,670 --> 00:35:03,760
is essentially equal to its year and

852
00:35:08,950 --> 00:35:05,680
it's only showing the same side to

853
00:35:12,630 --> 00:35:10,870
so this would be an in

854
00:35:13,750 --> 00:35:12,640
opposite to the case of a rapidly

855
00:35:16,390 --> 00:35:13,760
rotating

856
00:35:18,950 --> 00:35:16,400
planet like our earth which orbits once

857
00:35:24,230 --> 00:35:18,960
and i mean rotates once in 24 hours

858
00:35:30,630 --> 00:35:27,670
in this case we've got that rotation

859
00:35:33,030 --> 00:35:30,640
one rotation for one orbit

860
00:35:34,790 --> 00:35:33,040
and what we can see from this data uh

861
00:35:36,630 --> 00:35:34,800
most recently pulled from the nasa

862
00:35:38,710 --> 00:35:36,640
exoplanet archives that there's a large

863
00:35:40,950 --> 00:35:38,720

fraction of planets that we already know

864
00:35:42,150 --> 00:35:40,960
of that are orbiting m dwarfs right in

865
00:35:45,349 --> 00:35:42,160
this this

866
00:35:46,950 --> 00:35:45,359
um orbital period and and mass space and

867
00:35:49,109 --> 00:35:46,960
so this is um

868
00:35:53,430 --> 00:35:49,119
a quite significant fraction of the

869
00:35:57,430 --> 00:35:55,270
and and study further

870
00:35:59,270 --> 00:35:57,440
and so i i started to have this this

871
00:36:00,950 --> 00:35:59,280
thought recently of like what would

872
00:36:02,870 --> 00:36:00,960
happen if you have

873
00:36:05,829 --> 00:36:02,880
you have a synchronous planet

874
00:36:08,150 --> 00:36:05,839
synchronously rotating planet and

875
00:36:09,670 --> 00:36:08,160
could you have a scenario where it's so

876
00:36:11,030 --> 00:36:09,680
so hot on the day side that it's

877
00:36:13,589 --> 00:36:11,040
uninhabitable

878
00:36:15,829 --> 00:36:13,599
and it's so so cold on the night side

879
00:36:17,910 --> 00:36:15,839
that it's uninhabitable

880
00:36:20,390 --> 00:36:17,920
could you have a scenario where

881
00:36:22,310 --> 00:36:20,400
the only place the planet could exist

882
00:36:24,390 --> 00:36:22,320
could exist in in surface habitable

883
00:36:28,069 --> 00:36:24,400
conditions is along the dividing line

884
00:36:32,790 --> 00:36:30,230
and we call this scenario terminator

885
00:36:35,829 --> 00:36:32,800
habitability and my

886
00:36:38,630 --> 00:36:35,839
postdoc ana lobo has

887
00:36:40,470 --> 00:36:38,640
studied this and quantified whether this

888
00:36:42,470 --> 00:36:40,480

terminator habitability scenario could

889
00:36:44,870 --> 00:36:42,480
be possible on synchronously rotating

890
00:36:46,150 --> 00:36:44,880
ammo dwarf planets

891
00:36:48,870 --> 00:36:46,160
and of course i always think of the

892
00:36:50,069 --> 00:36:48,880
movie when i say terminator habitability

893
00:36:50,950 --> 00:36:50,079
um

894
00:36:53,430 --> 00:36:50,960
so

895
00:36:54,470 --> 00:36:53,440
what we find is that it is possible but

896
00:36:55,190 --> 00:36:54,480
it depends

897
00:36:57,349 --> 00:36:55,200
so

898
00:36:59,510 --> 00:36:57,359
what you're seeing here is

899
00:37:01,910 --> 00:36:59,520
temperature as a function of distance

900
00:37:03,990 --> 00:37:01,920
from the star these dots are the maximum

901
00:37:05,430 --> 00:37:04,000
and minimum surface temperatures so it's

902
00:37:06,870 --> 00:37:05,440
going to make more sense the more i go

903
00:37:09,030 --> 00:37:06,880
through it so

904
00:37:11,030 --> 00:37:09,040
what we find is that so minimum and

905
00:37:12,150 --> 00:37:11,040
maximum surface temperatures on an ocean

906
00:37:16,950 --> 00:37:12,160
planet

907
00:37:19,270 --> 00:37:16,960
increase the flux you're ending up

908
00:37:22,310 --> 00:37:19,280
evening out the day night temperature

909
00:37:24,230 --> 00:37:22,320
gradients and you do that essentially

910
00:37:26,550 --> 00:37:24,240
before you approach the runaway

911
00:37:29,030 --> 00:37:26,560
greenhouse state or

912
00:37:32,390 --> 00:37:29,040
you just so you do that

913
00:37:36,470 --> 00:37:34,630

or as you put this planet closer to the

914
00:37:38,950 --> 00:37:36,480
star it just becomes a runaway

915
00:37:42,069 --> 00:37:38,960
greenhouse with with both minimum and

916
00:37:44,310 --> 00:37:42,079
maximum being right super high

917
00:37:47,750 --> 00:37:44,320
so we're not able to get this terminator

918
00:37:51,109 --> 00:37:47,760
habitability scenario on an ocean planet

919
00:37:53,829 --> 00:37:51,119
but we can get it on a land planet

920
00:37:57,750 --> 00:37:53,839
in a water limited regime

921
00:38:03,990 --> 00:37:59,750
these extreme

922
00:38:06,150 --> 00:38:04,000
maximum and extreme minimum temperatures

923
00:38:06,870 --> 00:38:06,160
rather than in the ocean situation where

924
00:38:11,430 --> 00:38:06,880
we

925
00:38:13,030 --> 00:38:11,440
it's either homogeneous relatively

926
00:38:18,390 --> 00:38:13,040
homogeneous

927
00:38:21,589 --> 00:38:18,400
right in a land water limited regime we

928
00:38:24,310 --> 00:38:21,599
can get more extreme temperatures and

929
00:38:26,470 --> 00:38:24,320
um and have that kind of clement

930
00:38:28,710 --> 00:38:26,480
condition along the terminator

931
00:38:29,910 --> 00:38:28,720
and it might be that these water limited

932
00:38:32,550 --> 00:38:29,920
regimes

933
00:38:35,109 --> 00:38:32,560
are more common already we have some

934
00:38:37,349 --> 00:38:35,119
some theoretical work that's shown that

935
00:38:39,510 --> 00:38:37,359
water limited scenarios might be more

936
00:38:42,870 --> 00:38:39,520
common on m dwarfs in general

937
00:38:45,270 --> 00:38:42,880
and they might be potentially a stable

938
00:38:47,910 --> 00:38:45,280

configuration for planets around m

939
00:38:51,510 --> 00:38:47,920
dwarfs that undergo significant ocean

940
00:38:57,030 --> 00:38:54,550
we also came back to this eccentricity

941
00:38:59,190 --> 00:38:57,040
question because again a planet could

942
00:39:01,829 --> 00:38:59,200
cycle you could imagine a planet cycling

943
00:39:04,870 --> 00:39:01,839
in and out of habitable conditions over

944
00:39:07,589 --> 00:39:04,880
the course of its extreme orbit

945
00:39:09,910 --> 00:39:07,599
perhaps atmospheric gases condense out

946
00:39:12,150 --> 00:39:09,920
onto the surface and then sublimate back

947
00:39:13,990 --> 00:39:12,160
into the atmosphere like what could that

948
00:39:15,670 --> 00:39:14,000
do to habitability

949
00:39:17,270 --> 00:39:15,680
do we even know about what this the

950
00:39:18,950 --> 00:39:17,280
albedo parameterization for these

951
00:39:20,950 --> 00:39:18,960
alternative ice

952
00:39:23,109 --> 00:39:20,960
ices would be

953
00:39:25,430 --> 00:39:23,119
and and the answer is yes

954
00:39:29,109 --> 00:39:25,440
we've started to work with

955
00:39:30,790 --> 00:39:29,119
co2 ice which would be thinking about uh

956
00:39:33,670 --> 00:39:30,800
condensing out onto the surface at about

957
00:39:37,430 --> 00:39:33,680
minus 78.5 celsius

958
00:39:39,430 --> 00:39:37,440
many methane has as condenses at this

959
00:39:41,670 --> 00:39:39,440
much much lower temperature and so

960
00:39:42,870 --> 00:39:41,680
that's sort of next on our on our list

961
00:39:44,069 --> 00:39:42,880
to do

962
00:39:46,470 --> 00:39:44,079
but

963
00:39:49,109 --> 00:39:46,480

my grad student video venkatesan has

964
00:39:51,589 --> 00:39:49,119
found that this hysteresis trend when we

965
00:39:52,710 --> 00:39:51,599
look at hysteresis curves for eccentric

966
00:39:54,550 --> 00:39:52,720
planets

967
00:39:56,630 --> 00:39:54,560
when you incorporate an albedo

968
00:39:59,670 --> 00:39:56,640
parameterization for the formation of

969
00:40:01,109 --> 00:39:59,680
co2 ice on the surface you're able to

970
00:40:03,430 --> 00:40:01,119
amplify

971
00:40:07,109 --> 00:40:03,440
the differences in hysteresis between an

972
00:40:08,230 --> 00:40:07,119
m dwarf and an f dwarf planet

973
00:40:11,349 --> 00:40:08,240
and i'm going to leave it at that

974
00:40:13,510 --> 00:40:11,359
because she's got her eye poster that's

975
00:40:15,829 --> 00:40:13,520
uh that's currently you can look at

976
00:40:17,829 --> 00:40:15,839
right now so everyone in the room take

977
00:40:19,829 --> 00:40:17,839
out your phone and scan this qr code

978
00:40:21,829 --> 00:40:19,839
because it will pull up the poster and

979
00:40:23,990 --> 00:40:21,839
then you'll be all set for tomorrow

980
00:40:26,150 --> 00:40:24,000
because that is when she'll be there for

981
00:40:29,109 --> 00:40:26,160
an online discussion section at one

982
00:40:31,030 --> 00:40:29,119
o'clock so her her work the radio

983
00:40:33,190 --> 00:40:31,040
effects of carbon dioxide ice on the

984
00:40:35,910 --> 00:40:33,200
climate stability of extrasolar planets

985
00:40:38,069 --> 00:40:35,920
um is quite exciting because we haven't

986
00:40:40,950 --> 00:40:38,079
and many and not many people have

987
00:40:43,270 --> 00:40:40,960
incorporated these alternative ices into

988
00:40:45,030 --> 00:40:43,280

climate models and so we're starting

989
00:40:47,829 --> 00:40:45,040
with the ebms and we're going to move

990
00:40:49,750 --> 00:40:47,839
our way up to the to the gcms

991
00:40:51,270 --> 00:40:49,760
and there's you'd be hard-pressed to

992
00:40:53,670 --> 00:40:51,280
find someone more excited about

993
00:40:56,470 --> 00:40:53,680
exoplanets nvidia and this is her first

994
00:40:57,829 --> 00:40:56,480
abs icon so if you haven't met her yet

995
00:41:02,150 --> 00:40:57,839
go up to her and introduce yourself

996
00:41:06,710 --> 00:41:04,309
it's also important given that we talk

997
00:41:08,630 --> 00:41:06,720
so much about models and how and there's

998
00:41:10,470 --> 00:41:08,640
many many models that that those of us

999
00:41:11,990 --> 00:41:10,480
in the community are using

1000
00:41:13,510 --> 00:41:12,000
to

1001
00:41:15,430 --> 00:41:13,520
inter-compare

1002
00:41:16,870 --> 00:41:15,440
because models have different inputs

1003
00:41:18,870 --> 00:41:16,880
different parameterizations different

1004
00:41:21,910 --> 00:41:18,880
radiative transfer schemes

1005
00:41:23,670 --> 00:41:21,920
and the output the resultant output can

1006
00:41:25,430 --> 00:41:23,680
differ and so

1007
00:41:28,550 --> 00:41:25,440
many of us in this community of

1008
00:41:31,190 --> 00:41:28,560
exoplanet climate modeling have formed

1009
00:41:32,950 --> 00:41:31,200
model intercomparison teams

1010
00:41:35,510 --> 00:41:32,960
and one of those intercomparison

1011
00:41:38,870 --> 00:41:35,520
projects is being presented here uh

1012
00:41:41,589 --> 00:41:38,880
later today at 3 25 p.m uh jacob

1013
00:41:42,550 --> 00:41:41,599

hackmistra is going to be presenting um

1014
00:41:44,630 --> 00:41:42,560
our

1015
00:41:46,630 --> 00:41:44,640
the analysis the sparse atmospheric

1016
00:41:47,349 --> 00:41:46,640
model sampling analysis intercomparison

1017
00:41:49,510 --> 00:41:47,359
for

1018
00:41:51,510 --> 00:41:49,520
uh mdorf planet habitability so samosa

1019
00:41:54,309 --> 00:41:51,520
for short so please do attend and learn

1020
00:41:58,630 --> 00:41:57,109
okay so i have a few minutes more and

1021
00:42:02,230 --> 00:41:58,640
now i want to get to

1022
00:42:04,230 --> 00:42:02,240
um kind of how i got into this field

1023
00:42:06,150 --> 00:42:04,240
especially because i know there might be

1024
00:42:07,349 --> 00:42:06,160
many undergraduates and graduate

1025
00:42:09,589 --> 00:42:07,359
students

1026
00:42:11,589 --> 00:42:09,599
who are in attendance and wondering you

1027
00:42:13,510 --> 00:42:11,599
know how did you get started that was

1028
00:42:15,190 --> 00:42:13,520
always helpful for me

1029
00:42:17,270 --> 00:42:15,200
as a student to find out what the

1030
00:42:19,910 --> 00:42:17,280
pathway looked like um

1031
00:42:22,069 --> 00:42:19,920
i have a book coming out in about a year

1032
00:42:24,230 --> 00:42:22,079
um i thought that publication and

1033
00:42:27,030 --> 00:42:24,240
academia had sometimes long lead times

1034
00:42:28,870 --> 00:42:27,040
but no then you publish out in uh the

1035
00:42:30,870 --> 00:42:28,880
popular press and

1036
00:42:33,030 --> 00:42:30,880
oh my god so

1037
00:42:34,790 --> 00:42:33,040
um i'm i cannot wait

1038
00:42:36,630 --> 00:42:34,800

obviously uh for it to be out in the

1039
00:42:39,030 --> 00:42:36,640
world um but i'm going to give you a

1040
00:42:41,109 --> 00:42:39,040
glimpse as to a little bit

1041
00:42:42,790 --> 00:42:41,119
of the background and uh what you'll see

1042
00:42:46,150 --> 00:42:42,800
you'll have to read the whole book to to

1043
00:42:47,829 --> 00:42:46,160
find out how it all works out but

1044
00:42:49,670 --> 00:42:47,839
i thought it's useful to talk about

1045
00:42:51,270 --> 00:42:49,680
where i come from

1046
00:42:53,190 --> 00:42:51,280
my grandmother

1047
00:42:55,670 --> 00:42:53,200
majored in math at tennessee state

1048
00:42:57,349 --> 00:42:55,680
university in the 1930s

1049
00:42:59,510 --> 00:42:57,359
she did not finish

1050
00:43:02,309 --> 00:42:59,520
and you can imagine as as

1051
00:43:05,030 --> 00:43:02,319
rare and

1052
00:43:08,390 --> 00:43:05,040
sparse as black women are in

1053
00:43:11,829 --> 00:43:08,400
in math and the sciences today

1054
00:43:15,270 --> 00:43:11,839
um imagine what it was like in the 1930s

1055
00:43:17,430 --> 00:43:15,280
but she continued to study math

1056
00:43:19,829 --> 00:43:17,440
when our life spans overlapped i

1057
00:43:21,829 --> 00:43:19,839
remember her having textbooks on her

1058
00:43:23,829 --> 00:43:21,839
bedside table and the counting textbooks

1059
00:43:26,069 --> 00:43:23,839
and she worked at miramar air force base

1060
00:43:27,910 --> 00:43:26,079
home of the blue angels and

1061
00:43:30,309 --> 00:43:27,920
she was a civil servant there and so she

1062
00:43:32,950 --> 00:43:30,319
i consider her someone who's passed her

1063
00:43:35,430 --> 00:43:32,960

love of math on to me

1064
00:43:37,030 --> 00:43:35,440
this is me and my mom at her master's

1065
00:43:39,430 --> 00:43:37,040
pudding ceremony she went on to get her

1066
00:43:41,829 --> 00:43:39,440
phd and was a professor of music theory

1067
00:43:43,829 --> 00:43:41,839
and composition for over 20 years

1068
00:43:45,990 --> 00:43:43,839
so i got the indication pretty early

1069
00:43:48,309 --> 00:43:46,000
that education was important

1070
00:43:49,430 --> 00:43:48,319
um this is my dad he's

1071
00:43:50,550 --> 00:43:49,440
a

1072
00:43:53,349 --> 00:43:50,560
performer

1073
00:43:55,510 --> 00:43:53,359
entrepreneur incredible business person

1074
00:43:57,510 --> 00:43:55,520
um and of course that i told you they

1075
00:43:58,470 --> 00:43:57,520
both were in a band

1076
00:44:00,230 --> 00:43:58,480
uh

1077
00:44:02,470 --> 00:44:00,240
i would play a game of asking you can

1078
00:44:03,349 --> 00:44:02,480
you find my parents and on this album

1079
00:44:06,069 --> 00:44:03,359
cover

1080
00:44:08,069 --> 00:44:06,079
um it's hard i can't even see who would

1081
00:44:09,349 --> 00:44:08,079
be pointing at them but i'll just give

1082
00:44:10,550 --> 00:44:09,359
you the punch line there they are right

1083
00:44:12,710 --> 00:44:10,560
there

1084
00:44:14,470 --> 00:44:12,720
um

1085
00:44:16,870 --> 00:44:14,480
so the facts

1086
00:44:18,870 --> 00:44:16,880
my parents are music musicians my

1087
00:44:20,309 --> 00:44:18,880
grandmother liked math studied it for a

1088
00:44:21,750 --> 00:44:20,319

while

1089
00:44:23,750 --> 00:44:21,760
and i learned early on that school was

1090
00:44:26,309 --> 00:44:23,760
important but no one ever told me you

1091
00:44:29,510 --> 00:44:26,319
know you should be a scientist um

1092
00:44:31,109 --> 00:44:29,520
i fell in love with the stars and never

1093
00:44:34,950 --> 00:44:31,119
quite fell out

1094
00:44:38,950 --> 00:44:37,109
when i was 12 i saw this movie called

1095
00:44:40,390 --> 00:44:38,960
space camp and

1096
00:44:43,589 --> 00:44:40,400
even though it might not be considered

1097
00:44:45,829 --> 00:44:43,599
an academy award contender it changed my

1098
00:44:48,630 --> 00:44:45,839
life i i wanted to be an astronaut i ran

1099
00:44:50,950 --> 00:44:48,640
home got out the world book encyclopedia

1100
00:44:53,030 --> 00:44:50,960
volume a and looked up astronaut and

1101
00:44:55,990 --> 00:44:53,040
astronomy and sort of charted out my

1102
00:44:57,510 --> 00:44:56,000
entire career path that day at age 12. i

1103
00:44:59,670 --> 00:44:57,520
was going to go to mit and then

1104
00:45:02,710 --> 00:44:59,680
eventually apply to nasa

1105
00:45:04,790 --> 00:45:02,720
and i did go to mit

1106
00:45:07,589 --> 00:45:04,800
and then i started a phd program right

1107
00:45:09,510 --> 00:45:07,599
out of college pretty much on autopilot

1108
00:45:11,030 --> 00:45:09,520
not really making a conscious choice

1109
00:45:12,390 --> 00:45:11,040
which i consider one of the things that

1110
00:45:14,870 --> 00:45:12,400
i did wrong

1111
00:45:16,309 --> 00:45:14,880
i also because i was so distracted i

1112
00:45:18,950 --> 00:45:16,319
started acting

1113
00:45:21,190 --> 00:45:18,960

in high school and realized i loved it i

1114
00:45:24,230 --> 00:45:21,200
even started doing it at mit

1115
00:45:26,710 --> 00:45:24,240
and was conflicted and again didn't

1116
00:45:29,109 --> 00:45:26,720
really give myself a chance to ask those

1117
00:45:31,270 --> 00:45:29,119
questions those powerful questions that

1118
00:45:33,589 --> 00:45:31,280
some of which i asked you to ask at the

1119
00:45:34,950 --> 00:45:33,599
beginning of the talk with the

1120
00:45:36,630 --> 00:45:34,960
meditation

1121
00:45:39,349 --> 00:45:36,640
because questions are important and

1122
00:45:41,589 --> 00:45:39,359
questions um lead to

1123
00:45:43,910 --> 00:45:41,599
answers you know and because i didn't

1124
00:45:46,710 --> 00:45:43,920
take that time i was sort of

1125
00:45:48,069 --> 00:45:46,720
on that autopilot and once being

1126
00:45:51,750 --> 00:45:48,079
distracted

1127
00:45:54,069 --> 00:45:51,760
grades sort of suffered i isolated

1128
00:45:56,630 --> 00:45:54,079
so i looked around me and i thought well

1129
00:45:58,630 --> 00:45:56,640
no one looks like me they all kind of

1130
00:45:59,510 --> 00:45:58,640
you know have a certain look

1131
00:46:02,790 --> 00:45:59,520
um

1132
00:46:03,990 --> 00:46:02,800
and i loved sci-fi films and tv and i i

1133
00:46:06,550 --> 00:46:04,000
had this thing where i didn't know if i

1134
00:46:08,309 --> 00:46:06,560
wanted to be doing the the

1135
00:46:10,390 --> 00:46:08,319
things that the characters were doing in

1136
00:46:12,230 --> 00:46:10,400
space or in the deep ocean or if i

1137
00:46:13,510 --> 00:46:12,240
wanted to be doing the things the actors

1138
00:46:14,710 --> 00:46:13,520

were portraying the characters we're

1139
00:46:16,710 --> 00:46:14,720
doing

1140
00:46:17,750 --> 00:46:16,720
um and so everybody around me looked

1141
00:46:20,550 --> 00:46:17,760
sort of

1142
00:46:21,270 --> 00:46:20,560
like this and i

1143
00:46:36,470 --> 00:46:21,280
i

1144
00:46:38,630 --> 00:46:36,480
and so

1145
00:46:40,790 --> 00:46:38,640
i did a lot of cool things

1146
00:46:43,109 --> 00:46:40,800
out in la i acted in a film that went to

1147
00:46:45,750 --> 00:46:43,119
sundance and was ebert and roper's top

1148
00:46:48,470 --> 00:46:45,760
10 films of 2005. i hosted a science

1149
00:46:50,470 --> 00:46:48,480
show i did a lot of greek tragedy um but

1150
00:46:52,150 --> 00:46:50,480
i couldn't stop thinking about the sky

1151
00:46:54,470 --> 00:46:52,160
and occasionally i would look up and i'd

1152
00:46:56,069 --> 00:46:54,480
see a star through the smoke the through

1153
00:46:57,030 --> 00:46:56,079
the smoke sometimes smoke through the

1154
00:46:59,349 --> 00:46:57,040
smog

1155
00:47:00,630 --> 00:46:59,359
um and i would think about the life

1156
00:47:01,430 --> 00:47:00,640
before

1157
00:47:03,589 --> 00:47:01,440
um

1158
00:47:05,510 --> 00:47:03,599
and so i took a day job working for the

1159
00:47:09,030 --> 00:47:05,520
spitzer space telescope and that was

1160
00:47:11,430 --> 00:47:09,040
really my my gateway back into um

1161
00:47:12,710 --> 00:47:11,440
astronomy i applied again to grad

1162
00:47:14,470 --> 00:47:12,720
schools

1163
00:47:16,550 --> 00:47:14,480

i got in

1164
00:47:18,390 --> 00:47:16,560
to the university of washington

1165
00:47:19,510 --> 00:47:18,400
and i decided to exchange my life in

1166
00:47:20,950 --> 00:47:19,520
hollywood

1167
00:47:24,069 --> 00:47:20,960
for a life

1168
00:47:26,390 --> 00:47:24,079
in the pacific northwest

1169
00:47:28,630 --> 00:47:26,400
what i did right there

1170
00:47:30,710 --> 00:47:28,640
i basically did any

1171
00:47:33,430 --> 00:47:30,720
mentorship program that i found out

1172
00:47:35,270 --> 00:47:33,440
about for people who were or women

1173
00:47:37,109 --> 00:47:35,280
specifically who were returning to

1174
00:47:39,430 --> 00:47:37,119
school after a long time away it had

1175
00:47:40,470 --> 00:47:39,440
been 11 years since that first phd

1176
00:47:41,829 --> 00:47:40,480
program in

1177
00:47:43,510 --> 00:47:41,839
astrophysics

1178
00:47:45,510 --> 00:47:43,520
there was a process group for graduate

1179
00:47:47,750 --> 00:47:45,520
women of color i did that

1180
00:47:50,390 --> 00:47:47,760
when when things were challenging i did

1181
00:47:52,069 --> 00:47:50,400
not isolate i showed up for the qual

1182
00:47:53,430 --> 00:47:52,079
study groups i didn't try to study on my

1183
00:47:55,750 --> 00:47:53,440
own when everybody else was studying

1184
00:47:57,990 --> 00:47:55,760
together i planted myself in those

1185
00:48:00,069 --> 00:47:58,000
groups and studied with them

1186
00:48:01,829 --> 00:48:00,079
so i said yes to community rather than

1187
00:48:04,470 --> 00:48:01,839
isolating

1188
00:48:07,349 --> 00:48:04,480

and yes to a life outside of academia

1189
00:48:09,589 --> 00:48:07,359
and but i was i was focused we had my

1190
00:48:12,069 --> 00:48:09,599
husband and i had been had had good

1191
00:48:13,910 --> 00:48:12,079
paying jobs well-paying jobs and so to

1192
00:48:16,390 --> 00:48:13,920
come back to grad school meant i had to

1193
00:48:19,270 --> 00:48:16,400
want it bad but that was good for me

1194
00:48:21,589 --> 00:48:19,280
because it allowed me to be focused um

1195
00:48:26,069 --> 00:48:21,599
and and not distracted

1196
00:48:28,150 --> 00:48:26,079
so this is me at my phd hooding ceremony

1197
00:48:30,870 --> 00:48:28,160
this is me with uh with my husband

1198
00:48:33,190 --> 00:48:30,880
helping me with the hood um

1199
00:48:34,950 --> 00:48:33,200
he had 102 degree fever but he was not

1200
00:48:35,829 --> 00:48:34,960
going to miss that day and back in the

1201
00:48:37,829 --> 00:48:35,839
day

1202
00:48:39,829 --> 00:48:37,839
before covet people didn't mind you

1203
00:48:41,829 --> 00:48:39,839
showing up in public spaces with 102

1204
00:48:43,670 --> 00:48:41,839
degree fever so

1205
00:48:45,510 --> 00:48:43,680
this is me and my dad

1206
00:48:48,710 --> 00:48:45,520
we did not coordinate he is just that

1207
00:48:51,990 --> 00:48:50,549
and i also want to share this bit of

1208
00:48:52,870 --> 00:48:52,000
information for

1209
00:48:54,870 --> 00:48:52,880
um

1210
00:48:57,430 --> 00:48:54,880
students who might be looking for that

1211
00:48:59,990 --> 00:48:57,440
that thing that lights you up inside

1212
00:49:01,190 --> 00:49:00,000
that makes you want to study it

1213
00:49:02,870 --> 00:49:01,200

we're going to come full we're coming

1214
00:49:04,710 --> 00:49:02,880
full circle in this talk because i

1215
00:49:05,829 --> 00:49:04,720
talked with you about this water ice

1216
00:49:07,829 --> 00:49:05,839
property

1217
00:49:10,230 --> 00:49:07,839
how how i sort of fell in love with it

1218
00:49:11,990 --> 00:49:10,240
and that kind of formed the bulk of my

1219
00:49:13,910 --> 00:49:12,000
dissertation looking and exploring and

1220
00:49:15,750 --> 00:49:13,920
quantifying that phenomenon as a

1221
00:49:18,069 --> 00:49:15,760
function of post start type and

1222
00:49:20,710 --> 00:49:18,079
atmospheric composition well it all

1223
00:49:23,109 --> 00:49:20,720
started by me walking into the room

1224
00:49:25,589 --> 00:49:23,119
where a senior grad student was giving a

1225
00:49:27,430 --> 00:49:25,599
journal club talk on this paper

1226
00:49:28,950 --> 00:49:27,440
how water ice and snow albedo could be

1227
00:49:33,990 --> 00:49:28,960
suppressed

1228
00:49:36,309 --> 00:49:34,000
planets orbiting red dwarf stars

1229
00:49:39,030 --> 00:49:36,319
and so that was that moment for me that

1230
00:49:40,630 --> 00:49:39,040
light bulb went off and i went bingo

1231
00:49:42,710 --> 00:49:40,640
that's what i want to do

1232
00:49:44,390 --> 00:49:42,720
um and i reached out to the first author

1233
00:49:46,390 --> 00:49:44,400
manos joshi and

1234
00:49:48,390 --> 00:49:46,400
and sort of the rest is history so to

1235
00:49:49,910 --> 00:49:48,400
speak we ended up writing a couple of

1236
00:49:53,349 --> 00:49:49,920
papers together

1237
00:49:55,750 --> 00:49:53,359
um with other collaborators too and um

1238
00:49:57,270 --> 00:49:55,760

so what i want to say about that is

1239
00:49:58,790 --> 00:49:57,280
if you're at this conference and

1240
00:50:01,030 --> 00:49:58,800
something that you hear

1241
00:50:03,270 --> 00:50:01,040
really resonates with you go up to the

1242
00:50:05,030 --> 00:50:03,280
speaker afterwards right ask them if

1243
00:50:07,349 --> 00:50:05,040
they can go for lunch or at least for

1244
00:50:10,150 --> 00:50:07,359
five minutes during the coffee hour

1245
00:50:12,069 --> 00:50:10,160
talk with them or email them later if

1246
00:50:15,109 --> 00:50:12,079
you don't get a chance to talk with them

1247
00:50:17,510 --> 00:50:15,119
in person right be proactive my grad

1248
00:50:20,150 --> 00:50:17,520
student nvidia the reason i mean many of

1249
00:50:22,710 --> 00:50:20,160
much of why she's in our program is

1250
00:50:25,750 --> 00:50:22,720
because she came up to me after a talk i

1251
00:50:27,589 --> 00:50:25,760
gave at double a s many years ago and

1252
00:50:29,430 --> 00:50:27,599
introduced herself and talked about how

1253
00:50:30,790 --> 00:50:29,440
excited she was about exoplanets and

1254
00:50:31,990 --> 00:50:30,800
habitability

1255
00:50:33,589 --> 00:50:32,000
and then she worked for me for the

1256
00:50:35,190 --> 00:50:33,599
summer as an undergrad

1257
00:50:36,069 --> 00:50:35,200
and then joined our group as a grad

1258
00:50:39,030 --> 00:50:36,079
student

1259
00:50:40,950 --> 00:50:39,040
so um there's so much that is out of our

1260
00:50:42,950 --> 00:50:40,960
control but there's quite a bit that

1261
00:50:45,750 --> 00:50:42,960
isn't and for students it's good to

1262
00:50:48,069 --> 00:50:45,760
learn how to be proactive early go after

1263
00:50:49,670 --> 00:50:48,079

for go after what you want

1264
00:50:51,829 --> 00:50:49,680
um

1265
00:50:54,390 --> 00:50:51,839
the main message of this book which i

1266
00:50:57,670 --> 00:50:54,400
hope you'll all um

1267
00:51:00,470 --> 00:50:57,680
read and and appreciate is that there's

1268
00:51:03,190 --> 00:51:00,480
no one way to be a scientist

1269
00:51:05,349 --> 00:51:03,200
i didn't have any role models for what i

1270
00:51:08,390 --> 00:51:05,359
wanted to do and who i wanted to be and

1271
00:51:10,790 --> 00:51:08,400
once i realized that that was okay

1272
00:51:12,710 --> 00:51:10,800
so much got a lot easier we can be our

1273
00:51:16,390 --> 00:51:12,720
own role model

1274
00:51:19,829 --> 00:51:16,400
and there's no one way to do anything

1275
00:51:21,109 --> 00:51:19,839
i have a full life today

1276
00:51:22,950 --> 00:51:21,119
and

1277
00:51:23,829 --> 00:51:22,960
i have hobbies

1278
00:51:25,109 --> 00:51:23,839
i

1279
00:51:26,790 --> 00:51:25,119
try to

1280
00:51:30,390 --> 00:51:26,800
and i i've been pretty successful at

1281
00:51:33,349 --> 00:51:30,400
this i try to work this job that i have

1282
00:51:35,670 --> 00:51:33,359
in 40 hours or less and

1283
00:51:37,510 --> 00:51:35,680
people don't talk a lot about that um

1284
00:51:39,829 --> 00:51:37,520
maybe because everybody is working a lot

1285
00:51:40,870 --> 00:51:39,839
more but also because there's a sort of

1286
00:52:24,150 --> 00:51:40,880
a

1287
00:52:25,829 --> 00:52:24,160
underrepresented in the sciences

1288
00:52:27,589 --> 00:52:25,839

and we encourage these girls of all

1289
00:52:29,910 --> 00:52:27,599
colors and backgrounds to explore and

1290
00:52:32,390 --> 00:52:29,920
discover the universe using theater

1291
00:52:34,150 --> 00:52:32,400
writing and visual art just as there

1292
00:52:36,069 --> 00:52:34,160
would be so much we'd miss out on if we

1293
00:52:37,589 --> 00:52:36,079
looked at the milky way galaxy in just

1294
00:52:38,870 --> 00:52:37,599
one type of light

1295
00:52:42,549 --> 00:52:38,880
than if we looked in multiple

1296
00:52:44,549 --> 00:52:42,559
wavelengths so much

1297
00:52:46,630 --> 00:52:44,559
so too is there is there much more to

1298
00:52:49,190 --> 00:52:46,640
these girls than what meets the eye and

1299
00:52:52,470 --> 00:52:49,200
so um we've had a lot of success both

1300
00:52:54,790 --> 00:52:52,480
with in-person workshops prior to covid

1301
00:52:55,510 --> 00:52:54,800
and now virtually so this is an example

1302
00:52:59,670 --> 00:52:55,520
of

1303
00:53:02,870 --> 00:52:59,680
participants designed herself and made

1304
00:53:06,790 --> 00:53:02,880
choices about its its land surface and

1305
00:53:08,549 --> 00:53:06,800
topography and its um its this type of

1306
00:53:10,710 --> 00:53:08,559
sun in the sky

1307
00:53:13,030 --> 00:53:10,720
that would be seen

1308
00:53:14,790 --> 00:53:13,040
we do this because we want girls to

1309
00:53:15,750 --> 00:53:14,800
understand that

1310
00:53:19,670 --> 00:53:15,760
that

1311
00:53:21,109 --> 00:53:19,680
personal to what they're learning and so

1312
00:53:23,349 --> 00:53:21,119
it's not just about

1313
00:53:25,349 --> 00:53:23,359

teaching them facts about the universe

1314
00:53:27,750 --> 00:53:25,359
but if they've written a poem about a

1315
00:53:29,589 --> 00:53:27,760
star or a galaxy if they've designed an

1316
00:53:31,670 --> 00:53:29,599
exoplanet and made choices about its

1317
00:53:33,990 --> 00:53:31,680
environment then hopefully they'll be

1318
00:53:38,230 --> 00:53:34,000
less likely to abandon their interest in

1319
00:53:39,829 --> 00:53:38,240
astronomy once the heavy math comes in

1320
00:53:41,829 --> 00:53:39,839
and that's the goal so we conducted our

1321
00:53:42,950 --> 00:53:41,839
first virtual workshop

1322
00:53:44,870 --> 00:53:42,960
last year

1323
00:53:47,349 --> 00:53:44,880
and with over 40 girls across the

1324
00:53:49,270 --> 00:53:47,359
country and it was a roaring success

1325
00:53:51,829 --> 00:53:49,280
these are our co-facilitators a grad

1326
00:53:53,910 --> 00:53:51,839
student maya silverman undergrad kiana

1327
00:53:55,670 --> 00:53:53,920
whitfield who's starting in a phd

1328
00:53:57,349 --> 00:53:55,680
program at university of maryland in the

1329
00:53:59,190 --> 00:53:57,359
fall

1330
00:54:00,790 --> 00:53:59,200
and jessica nicole howard who's off

1331
00:54:03,670 --> 00:54:00,800
camera

1332
00:54:05,990 --> 00:54:03,680
just defended her phd dissertation here

1333
00:54:09,430 --> 00:54:06,000
at uci and is going to be starting at

1334
00:54:12,230 --> 00:54:09,440
cavley at ucsb in the fall

1335
00:54:13,990 --> 00:54:12,240
our my team is is an extraordinary team

1336
00:54:16,549 --> 00:54:14,000
and there's many others christina den

1337
00:54:18,150 --> 00:54:16,559
who's helped make this um this program

1338
00:54:19,109 --> 00:54:18,160

what it is and we're gearing up for our

1339
00:54:23,109 --> 00:54:19,119
next

1340
00:54:24,950 --> 00:54:23,119
season um this summer on virtual season

1341
00:54:27,589 --> 00:54:24,960
so for more information

1342
00:54:29,030 --> 00:54:27,599
please visit our website and

1343
00:54:31,270 --> 00:54:29,040
and let us know if you'd like to be

1344
00:54:33,589 --> 00:54:31,280
involved we'd love to have you

1345
00:54:35,829 --> 00:54:33,599
and lastly i want to say that

1346
00:54:37,750 --> 00:54:35,839
start building your mentorship network i

1347
00:54:39,589 --> 00:54:37,760
can't fit my mentors on one slide

1348
00:54:41,910 --> 00:54:39,599
anymore this this slide is outdated

1349
00:54:43,990 --> 00:54:41,920
because there's just there's so many now

1350
00:54:46,870 --> 00:54:44,000
um again you find someone who has what

1351
00:54:49,109 --> 00:54:46,880
you want whether it's that grant that

1352
00:54:50,230 --> 00:54:49,119
career that place that they're living in

1353
00:54:52,549 --> 00:54:50,240
that city

1354
00:54:54,950 --> 00:54:52,559
you ask them if they have 20 minutes to

1355
00:54:56,710 --> 00:54:54,960
have a conversation that person becomes

1356
00:54:59,109 --> 00:54:56,720
a mentor so start building your

1357
00:55:02,390 --> 00:54:59,119
mentorship network early because science

1358
00:55:06,470 --> 00:55:02,400
is not an individual uh competition it's

1359
00:55:08,069 --> 00:55:06,480
a team sport start building your team

1360
00:55:10,150 --> 00:55:08,079
and that will hopefully allow you to

1361
00:55:11,829 --> 00:55:10,160
spend most of your career rather than

1362
00:55:18,309 --> 00:55:11,839
looking like this

1363
00:55:19,990 --> 00:55:18,319

or maybe even this wouldn't that be

1364
00:55:23,030 --> 00:55:20,000
wonderful

1365
00:55:26,069 --> 00:55:23,040
that is my wish for you

1366
00:55:27,750 --> 00:55:26,079
i want to thank all of my um

1367
00:55:30,950 --> 00:55:27,760
of my team

1368
00:55:32,470 --> 00:55:30,960
um the apps icon conference organizers

1369
00:55:34,630 --> 00:55:32,480
thank you so much for the invitation to

1370
00:55:37,190 --> 00:55:34,640
be here today and for making this

1371
00:55:39,030 --> 00:55:37,200
possible in a way that worked for me

1372
00:55:40,789 --> 00:55:39,040
thanks to my institution and my funding

1373
00:55:42,710 --> 00:55:40,799
sources and to my growing list of

1374
00:55:44,390 --> 00:55:42,720
collaborators it's an honor to have done

1375
00:55:47,349 --> 00:55:44,400
this work and to continue to do this

1376
00:55:47,359 --> 00:55:56,230
thank you all for your attention

1377
00:56:03,910 --> 00:55:57,349
thank you

1378
00:56:08,470 --> 00:56:06,309
so i think we have time for questions uh

1379
00:56:11,190 --> 00:56:08,480
so we have about six six minutes so

1380
00:56:13,030 --> 00:56:11,200
please come up to the mic i see i'm

1381
00:56:14,549 --> 00:56:13,040
gonna alternate between online and

1382
00:56:17,190 --> 00:56:14,559
in-person questions i'd like to go ahead

1383
00:56:19,430 --> 00:56:17,200
and start

1384
00:56:21,829 --> 00:56:19,440
hi i'm marshall staccinski i'm a

1385
00:56:23,109 --> 00:56:21,839
post-doc at jpl and a recent graduate of

1386
00:56:25,190 --> 00:56:23,119
the university of washington

1387
00:56:27,109 --> 00:56:25,200
astrobiology program and i really

1388
00:56:27,990 --> 00:56:27,119

appreciated the message that you had

1389
00:56:31,190 --> 00:56:28,000
about

1390
00:56:32,710 --> 00:56:31,200
having a community and i wondered what

1391
00:56:34,230 --> 00:56:32,720
tips you might have for people who don't

1392
00:56:35,589 --> 00:56:34,240
have the kind of automatic structure

1393
00:56:37,349 --> 00:56:35,599
that that program gives the grad

1394
00:56:40,230 --> 00:56:37,359
students there

1395
00:56:42,309 --> 00:56:40,240
for building community where they are

1396
00:56:44,549 --> 00:56:42,319
um yeah

1397
00:56:46,309 --> 00:56:44,559
the community especially in these times

1398
00:56:47,109 --> 00:56:46,319
thank you for that question um

1399
00:56:49,910 --> 00:56:47,119
can

1400
00:56:51,510 --> 00:56:49,920
we have such a facility to

1401
00:56:54,150 --> 00:56:51,520
to have this be

1402
00:56:56,710 --> 00:56:54,160
global um certainly across country and

1403
00:56:58,470 --> 00:56:56,720
maybe even across across the the pond so

1404
00:57:00,230 --> 00:56:58,480
to speak um

1405
00:57:03,270 --> 00:57:00,240
there are many

1406
00:57:06,789 --> 00:57:03,280
online mentoring um

1407
00:57:08,789 --> 00:57:06,799
avenues so i can think of sagan net

1408
00:57:10,470 --> 00:57:08,799
which several of my

1409
00:57:12,549 --> 00:57:10,480
colleagues and friends have run for a

1410
00:57:15,510 --> 00:57:12,559
while

1411
00:57:17,030 --> 00:57:15,520
and so sagan net i think saganette.org

1412
00:57:19,430 --> 00:57:17,040
where you can actually be i think you

1413
00:57:22,150 --> 00:57:19,440

can still be paired with a mentor but

1414
00:57:23,030 --> 00:57:22,160
they also have peer mentoring

1415
00:57:24,309 --> 00:57:23,040
and

1416
00:57:26,950 --> 00:57:24,319
there are

1417
00:57:29,190 --> 00:57:26,960
other opportunities like that if you so

1418
00:57:31,910 --> 00:57:29,200
i have a colleague jedidah eisler who's

1419
00:57:33,109 --> 00:57:31,920
conducted a um something called

1420
00:57:36,789 --> 00:57:33,119
um

1421
00:57:39,510 --> 00:57:36,799
vanguard stem for a while which is for

1422
00:57:41,430 --> 00:57:39,520
women who are in different stem fields

1423
00:57:43,990 --> 00:57:41,440
and there's online

1424
00:57:46,390 --> 00:57:44,000
interviews and panels and again peer

1425
00:57:48,069 --> 00:57:46,400
mentoring and um and mentoring at

1426
00:57:50,789 --> 00:57:48,079
different different levels different

1427
00:57:53,589 --> 00:57:50,799
tiered mentorships so i would say again

1428
00:57:55,349 --> 00:57:53,599
get proactive look online if so if no

1429
00:57:57,190 --> 00:57:55,359
one in your department

1430
00:57:59,910 --> 00:57:57,200
um if there's no like built-in

1431
00:58:01,190 --> 00:57:59,920
mentorship structure like in my in my

1432
00:58:03,270 --> 00:58:01,200
department we actually have a peer

1433
00:58:05,190 --> 00:58:03,280
mentoring system or grad students for

1434
00:58:07,589 --> 00:58:05,200
more senior or mentoring

1435
00:58:08,950 --> 00:58:07,599
incoming grad students if that doesn't

1436
00:58:11,190 --> 00:58:08,960
exist

1437
00:58:12,950 --> 00:58:11,200
you can either make it yourself again if

1438
00:58:14,789 --> 00:58:12,960

there's no role model there

1439
00:58:16,870 --> 00:58:14,799
you can be the role model

1440
00:58:19,030 --> 00:58:16,880
or you can get the help you need from

1441
00:58:20,950 --> 00:58:19,040
elsewhere ask your advisor if they could

1442
00:58:23,270 --> 00:58:20,960
connect you

1443
00:58:25,109 --> 00:58:23,280
at these conferences right now you could

1444
00:58:26,950 --> 00:58:25,119
start building some kind of a peer mor

1445
00:58:28,789 --> 00:58:26,960
mentorship network just with a few

1446
00:58:30,630 --> 00:58:28,799
people that you've met at at the

1447
00:58:33,349 --> 00:58:30,640
conference and stay in touch with each

1448
00:58:35,510 --> 00:58:33,359
other i actually was in touch with um i

1449
00:58:38,390 --> 00:58:35,520
had a postdoc women of color telecon for

1450
00:58:40,150 --> 00:58:38,400
several years and um

1451
00:58:41,910 --> 00:58:40,160
catherine esparya had set that up

1452
00:58:44,069 --> 00:58:41,920
through an nsf career

1453
00:58:46,710 --> 00:58:44,079
award that she had and now it's like

1454
00:58:49,270 --> 00:58:46,720
just totally magnified and exploded in

1455
00:58:51,670 --> 00:58:49,280
many different ways but i like every two

1456
00:58:53,589 --> 00:58:51,680
weeks i had a zoom with three other

1457
00:58:55,589 --> 00:58:53,599
post-docs who are also women of color in

1458
00:58:58,069 --> 00:58:55,599
astronomy and we just talked with each

1459
00:59:00,549 --> 00:58:58,079
other just having that sense of not

1460
00:59:03,109 --> 00:59:00,559
being alone is so crucial

1461
00:59:05,589 --> 00:59:03,119
so it might not look as organized or it

1462
00:59:07,750 --> 00:59:05,599
might not be as as kind of implemented

1463
00:59:09,750 --> 00:59:07,760

in place but you can find something that

1464
00:59:12,230 --> 00:59:09,760
works for you don't give up

1465
00:59:18,630 --> 00:59:16,069
great okay so i just want to share a few

1466
00:59:21,349 --> 00:59:18,640
comments online um one from sean domingo

1467
00:59:22,390 --> 00:59:21,359
goldman i am grateful for that mindful

1468
00:59:24,470 --> 00:59:22,400
moment

1469
00:59:26,789 --> 00:59:24,480
thank you

1470
00:59:29,270 --> 00:59:26,799
um andrew

1471
00:59:31,510 --> 00:59:29,280
steve vance said thank you for talking

1472
00:59:34,870 --> 00:59:31,520
about work-life balance

1473
00:59:36,230 --> 00:59:34,880
and andrew has a question from online

1474
00:59:37,589 --> 00:59:36,240
he says

1475
00:59:39,670 --> 00:59:37,599
m dwarf

1476
00:59:41,349 --> 00:59:39,680
and dwarf stars sometimes demonstrate

1477
00:59:43,430 --> 00:59:41,359
stellar cycles

1478
00:59:46,230 --> 00:59:43,440
causing their stellar light output to

1479
00:59:48,870 --> 00:59:46,240
vary by up to several percent cyclically

1480
00:59:51,430 --> 00:59:48,880
every few years to decades

1481
00:59:54,309 --> 00:59:51,440
how might this long-term variability

1482
00:59:55,430 --> 00:59:54,319
impact habitability

1483
01:00:00,789 --> 00:59:55,440
um

1484
01:00:03,030 --> 01:00:00,799
people for a long time have have talked

1485
01:00:04,950 --> 01:00:03,040
about this because those long lifetimes

1486
01:00:08,470 --> 01:00:04,960
of because of those long lifetimes of em

1487
01:00:10,230 --> 01:00:08,480
dwarfs um they have these extreme

1488
01:00:11,750 --> 01:00:10,240

this is this this period of extreme

1489
01:00:13,109 --> 01:00:11,760
stellar activity i know that's a little

1490
01:00:15,750 --> 01:00:13,119
bit different from what you're talking

1491
01:00:17,829 --> 01:00:15,760
about but the the end result is the same

1492
01:00:19,829 --> 01:00:17,839
right a lot more output so those

1493
01:00:21,349 --> 01:00:19,839
pre-made sequence phases can last on the

1494
01:00:23,030 --> 01:00:21,359
order of a billion years we think of

1495
01:00:25,349 --> 01:00:23,040
this almost like a terrible twos phase

1496
01:00:27,430 --> 01:00:25,359
for stars and

1497
01:00:29,190 --> 01:00:27,440
and yet even in sort of the more

1498
01:00:32,230 --> 01:00:29,200
quiescent phase you could still have

1499
01:00:34,230 --> 01:00:32,240
flare activity you could have this right

1500
01:00:36,390 --> 01:00:34,240
our own sun has its cycle that's right

1501
01:00:38,950 --> 01:00:36,400
so of course so too with em dwarfs

1502
01:00:42,789 --> 01:00:38,960
um it might be that

1503
01:00:44,630 --> 01:00:42,799
oops excuse me getting an adobe alert it

1504
01:00:46,549 --> 01:00:44,640
might be that

1505
01:00:49,270 --> 01:00:46,559
that pl habitability on the surface

1506
01:00:51,030 --> 01:00:49,280
could be challenging um that x uv

1507
01:00:52,630 --> 01:00:51,040
radiation certainly is harmful to

1508
01:00:54,630 --> 01:00:52,640
biology

1509
01:00:57,270 --> 01:00:54,640
but we certainly know

1510
01:00:59,910 --> 01:00:57,280
here on earth that life

1511
01:01:01,990 --> 01:00:59,920
exists every single place we can look

1512
01:01:03,670 --> 01:01:02,000
for it right even in super super water

1513
01:01:04,549 --> 01:01:03,680

limited regimes it's got to have some

1514
01:01:07,510 --> 01:01:04,559
water

1515
01:01:10,309 --> 01:01:07,520
but from the driest areas to the deepest

1516
01:01:12,230 --> 01:01:10,319
oceans life finds a way and so maybe on

1517
01:01:13,910 --> 01:01:12,240
this on these planets they could only

1518
01:01:15,910 --> 01:01:13,920
exist life could only exist at the

1519
01:01:17,589 --> 01:01:15,920
bottom of an ocean but that certainly is

1520
01:01:19,510 --> 01:01:17,599
is one way that um

1521
01:01:20,630 --> 01:01:19,520
that that could happen

1522
01:01:23,510 --> 01:01:20,640
great

1523
01:01:26,309 --> 01:01:23,520
i actually have another online question

1524
01:01:31,030 --> 01:01:26,319
how far can gcms be pushed with

1525
01:01:33,589 --> 01:01:31,040
increasing gpus or cpus on clusters are

1526
01:01:35,750 --> 01:01:33,599
we close to resolving small land

1527
01:01:38,470 --> 01:01:35,760
features that can interact with the

1528
01:01:40,390 --> 01:01:38,480
atmosphere like volcanoes

1529
01:01:42,390 --> 01:01:40,400
that's from ben pierce

1530
01:01:45,589 --> 01:01:42,400
hmm

1531
01:01:47,910 --> 01:01:45,599
so i know people are working on um kind

1532
01:01:50,069 --> 01:01:47,920
of getting our our grid cells if you

1533
01:01:52,870 --> 01:01:50,079
will to have a much more finer

1534
01:01:55,029 --> 01:01:52,880
resolution the the trade-off there is

1535
01:01:57,190 --> 01:01:55,039
that the finer your resolution the

1536
01:02:00,470 --> 01:01:57,200
longer it takes for you to run your your

1537
01:02:01,510 --> 01:02:00,480
your climate model um so typically

1538
01:02:03,190 --> 01:02:01,520

um

1539
01:02:05,910 --> 01:02:03,200
you know

1540
01:02:08,710 --> 01:02:05,920
hundreds of meters are on the order of

1541
01:02:10,870 --> 01:02:08,720
what kind of resolution that um

1542
01:02:12,309 --> 01:02:10,880
that in the ballpark

1543
01:02:13,910 --> 01:02:12,319
but um

1544
01:02:16,309 --> 01:02:13,920
but features

1545
01:02:17,430 --> 01:02:16,319
that's certainly not the the type those

1546
01:02:19,029 --> 01:02:17,440
aren't the type of models that i'm

1547
01:02:20,870 --> 01:02:19,039
running right now

1548
01:02:22,390 --> 01:02:20,880
again there are some models that in the

1549
01:02:24,069 --> 01:02:22,400
same way that there are models that will

1550
01:02:26,230 --> 01:02:24,079
that you can run with a fully dynamic

1551
01:02:27,910 --> 01:02:26,240
ocean and many of us and exoplanets are

1552
01:02:29,349 --> 01:02:27,920
doing that it takes a lot longer but

1553
01:02:32,150 --> 01:02:29,359
it's really important to include the

1554
01:02:33,670 --> 01:02:32,160
effect of ocean bathymetry um and then

1555
01:02:36,069 --> 01:02:33,680
again you have to decide like what's

1556
01:02:38,230 --> 01:02:36,079
more important if you if you assume a 50

1557
01:02:40,470 --> 01:02:38,240
meter slab ocean you're not getting

1558
01:02:42,710 --> 01:02:40,480
ocean heat flux which of course will

1559
01:02:45,190 --> 01:02:42,720
affect climate inhabitability but you

1560
01:02:47,670 --> 01:02:45,200
might be able to run a lot more models

1561
01:02:50,470 --> 01:02:47,680
and get some sort of first order idea of

1562
01:02:52,390 --> 01:02:50,480
what other factors might be influencing

1563
01:02:54,630 --> 01:02:52,400

climate and habitability

1564
01:02:56,710 --> 01:02:54,640
and and kind of do that separate from

1565
01:02:59,430 --> 01:02:56,720
the ocean so too can we do this with

1566
01:03:01,829 --> 01:02:59,440
land so we currently are in the process

1567
01:03:05,109 --> 01:03:01,839
of and have constrained the percentage

1568
01:03:07,670 --> 01:03:05,119
of land by the the overall or the effect

1569
01:03:10,470 --> 01:03:07,680
of land percentage the effect of land

1570
01:03:12,230 --> 01:03:10,480
surface composition um but getting to

1571
01:03:13,430 --> 01:03:12,240
that point where you're actually looking

1572
01:03:16,230 --> 01:03:13,440
at um

1573
01:03:18,470 --> 01:03:16,240
topography orography

1574
01:03:19,670 --> 01:03:18,480
that is very tricky if you're also

1575
01:03:21,910 --> 01:03:19,680
wanting to

1576
01:03:22,950 --> 01:03:21,920
explore all the other aspects of the

1577
01:03:26,470 --> 01:03:22,960
full

1578
01:03:30,390 --> 01:03:28,150
excellent

1579
01:03:32,549 --> 01:03:30,400
any other oh we have one more question

1580
01:03:33,990 --> 01:03:32,559
this is going to be our last question

1581
01:03:36,230 --> 01:03:34,000
yes thank you

1582
01:03:38,069 --> 01:03:36,240
excuse me uh hi i'm carlos cruz arsene

1583
01:03:39,670 --> 01:03:38,079
from nasa goddard uh thank you for your

1584
01:03:41,029 --> 01:03:39,680
talk and even more so thank you for what

1585
01:03:44,069 --> 01:03:41,039
you're doing for the kids

1586
01:03:45,990 --> 01:03:44,079
so um i know tons of kids that want to

1587
01:03:47,910 --> 01:03:46,000
become scientists but like you said

1588
01:03:49,510 --> 01:03:47,920

scientists don't really look like us

1589
01:03:51,910 --> 01:03:49,520
and i found that a lot of the times it's

1590
01:03:53,029 --> 01:03:51,920
the parents who have like internalized

1591
01:03:54,630 --> 01:03:53,039
that idea

1592
01:03:56,069 --> 01:03:54,640
and they don't support their kids trying

1593
01:03:59,220 --> 01:03:56,079
to become scientists so do you have any

1594
01:04:04,230 --> 01:03:59,230
advice on how to get the parent on board

1595
01:04:09,829 --> 01:04:06,870
you know one of the things that we

1596
01:04:11,589 --> 01:04:09,839
ask that the girls in our workshops at

1597
01:04:13,829 --> 01:04:11,599
the beginning and at the end of the

1598
01:04:15,270 --> 01:04:13,839
workshop we do these assessments and we

1599
01:04:17,430 --> 01:04:15,280
ask them to rate their level of

1600
01:04:19,430 --> 01:04:17,440
agreement on a series of questions and

1601
01:04:22,309 --> 01:04:19,440
one of the questions is i talk to my

1602
01:04:23,589 --> 01:04:22,319
family and friends about science

1603
01:04:25,670 --> 01:04:23,599
and

1604
01:04:28,630 --> 01:04:25,680
we usually

1605
01:04:30,789 --> 01:04:28,640
have seen that there's a difference

1606
01:04:33,029 --> 01:04:30,799
between how when we start the workshop

1607
01:04:35,349 --> 01:04:33,039
and when we end we end the workshop

1608
01:04:37,750 --> 01:04:35,359
that level of agreement on that of that

1609
01:04:40,710 --> 01:04:37,760
statement with that statement has

1610
01:04:42,470 --> 01:04:40,720
increased markedly for most of the girls

1611
01:04:43,990 --> 01:04:42,480
and so

1612
01:04:45,829 --> 01:04:44,000
yes of course you have to get the family

1613
01:04:48,390 --> 01:04:45,839

to be willing to allow their girls to

1614
01:04:50,789 --> 01:04:48,400
participate um and i think the way we've

1615
01:04:52,390 --> 01:04:50,799
tried to do that now for example where

1616
01:04:54,150 --> 01:04:52,400
we're

1617
01:04:57,190 --> 01:04:54,160
sharing the flyers and multiple

1618
01:04:59,349 --> 01:04:57,200
languages so many of the girls you know

1619
01:05:01,109 --> 01:04:59,359
they're there for the for those that are

1620
01:05:03,670 --> 01:05:01,119
here in the united states they're

1621
01:05:05,670 --> 01:05:03,680
learning english at at school but their

1622
01:05:08,950 --> 01:05:05,680
parents might speak a different language

1623
01:05:10,549 --> 01:05:08,960
at home and so that language barrier can

1624
01:05:12,710 --> 01:05:10,559
be an impediment to the parents just

1625
01:05:14,630 --> 01:05:12,720
simply understanding what this program

1626
01:05:16,230 --> 01:05:14,640
is that the girls might be interested in

1627
01:05:18,390 --> 01:05:16,240
so you know we outreach to the to the

1628
01:05:20,390 --> 01:05:18,400
schools directly and we send flyers home

1629
01:05:22,230 --> 01:05:20,400
both in english and in other languages

1630
01:05:24,470 --> 01:05:22,240
such as spanish

1631
01:05:26,309 --> 01:05:24,480
and that we found has made a difference

1632
01:05:27,990 --> 01:05:26,319
it's kind of been more inclusive

1633
01:05:29,349 --> 01:05:28,000
inclusive of the entire family

1634
01:05:32,470 --> 01:05:29,359
environment

1635
01:05:34,390 --> 01:05:32,480
not just the girls and that's a way to

1636
01:05:36,549 --> 01:05:34,400
to get them on board we also kind of

1637
01:05:38,549 --> 01:05:36,559
partner with the teachers who can then

1638
01:05:40,309 --> 01:05:38,559

help communicate to the parents hey this

1639
01:05:42,470 --> 01:05:40,319
is an important thing we'd love to offer

1640
01:05:43,829 --> 01:05:42,480
this enrichment opportunity to your to

1641
01:05:46,150 --> 01:05:43,839
your daughters

1642
01:05:47,270 --> 01:05:46,160
so those are some ideas and then

1643
01:05:49,109 --> 01:05:47,280
simply

1644
01:05:51,270 --> 01:05:49,119
doing this act these activities with the

1645
01:05:52,950 --> 01:05:51,280
girls at school we find that that

1646
01:05:55,109 --> 01:05:52,960
in the program we find that that does

1647
01:05:57,029 --> 01:05:55,119
translate to them sharing more about

1648
01:05:58,870 --> 01:05:57,039
what they're doing with their families

1649
01:06:00,549 --> 01:05:58,880
and um and that seems to make a

1650
01:06:01,910 --> 01:06:00,559
difference in the families being more

1651
01:06:03,029 --> 01:06:01,920
supportive

1652
01:06:05,029 --> 01:06:03,039
and we'll keep thinking of other ways

1653
01:06:06,950 --> 01:06:05,039
too because it's um it's an important

1654
01:06:09,029 --> 01:06:06,960
point that you bring up is you need to

1655
01:06:10,950 --> 01:06:09,039
have the support in the family to be

1656
01:06:13,829 --> 01:06:10,960
able to not just have a girl participate

1657
01:06:16,950 --> 01:06:13,839
in one program but also to hopefully

1658
01:06:18,950 --> 01:06:16,960
continue on in in that field if she

1659
01:06:21,190 --> 01:06:18,960
wants so i think having a continued

1660
01:06:23,270 --> 01:06:21,200
connection for example this year we have

1661
01:06:25,109 --> 01:06:23,280
two girls who participated last year

1662
01:06:26,710 --> 01:06:25,119
that have already registered for this

1663
01:06:28,549 --> 01:06:26,720

year to do it again because they loved

1664
01:06:31,190 --> 01:06:28,559
it so much so we're working on getting

1665
01:06:33,270 --> 01:06:31,200
that continuity as we transition to more

1666
01:06:35,589 --> 01:06:33,280
of a publication platform where we

1667
01:06:37,510 --> 01:06:35,599
actually publish our results and and

1668
01:06:38,789 --> 01:06:37,520
it's like seeing these girls through

1669
01:06:40,870 --> 01:06:38,799
we're not just interested in getting

1670
01:06:42,870 --> 01:06:40,880
them started but but providing some kind

1671
01:06:43,829 --> 01:06:42,880
of a continuity framework we can

1672
01:06:46,069 --> 01:06:43,839
actually

1673
01:06:48,549 --> 01:06:46,079
mentor them as they proceed through

1674
01:06:50,789 --> 01:06:48,559
their academic careers

1675
01:06:52,710 --> 01:06:50,799
thank you so much excellent

1676
01:06:55,190 --> 01:06:52,720
well we did have one more question come

1677
01:06:56,870 --> 01:06:55,200
in if i can sneak one more exoplanet

1678
01:06:58,309 --> 01:06:56,880
question in

1679
01:07:02,309 --> 01:06:58,319
from omri

1680
01:07:08,390 --> 01:07:02,319
wandel says by how much can geothermal

1681
01:07:12,390 --> 01:07:10,710
yeah so this depends on

1682
01:07:14,870 --> 01:07:12,400
the planet

1683
01:07:17,910 --> 01:07:14,880
on our planet our geothermal heat flux

1684
01:07:20,870 --> 01:07:17,920
is about 0.08 watts per meter squared

1685
01:07:22,950 --> 01:07:20,880
so it's not certainly not as significant

1686
01:07:26,870 --> 01:07:22,960
as

1687
01:07:28,630 --> 01:07:26,880
other energy flows but it's

1688
01:07:30,789 --> 01:07:28,640

it's not negligible

1689
01:07:33,029 --> 01:07:30,799
um that's something that we haven't

1690
01:07:34,390 --> 01:07:33,039
explored yet but

1691
01:07:36,390 --> 01:07:34,400
that i think this is a wonderful

1692
01:07:39,109 --> 01:07:36,400
opportunity and i know that others there

1693
01:07:41,670 --> 01:07:39,119
at absycon have have given talks about

1694
01:07:43,910 --> 01:07:41,680
this the sort of synergy between

1695
01:07:45,910 --> 01:07:43,920
the exoplanet community solar system

1696
01:07:48,150 --> 01:07:45,920
community

1697
01:07:51,349 --> 01:07:48,160
and and the climate and atmosphere

1698
01:07:53,670 --> 01:07:51,359
modeling and earth science community

1699
01:07:56,150 --> 01:07:53,680
so that we can look at right the effects

1700
01:07:58,309 --> 01:07:56,160
of geothermal heating

1701
01:08:00,630 --> 01:07:58,319
of course if we've got

1702
01:08:02,710 --> 01:08:00,640
tides happening like that there's that's

1703
01:08:04,710 --> 01:08:02,720
why the habitable zone on its and its

1704
01:08:07,270 --> 01:08:04,720
own traditional definition is so

1705
01:08:09,829 --> 01:08:07,280
limiting even if you have planets that

1706
01:08:12,150 --> 01:08:09,839
or moons that are super super far away

1707
01:08:13,829 --> 01:08:12,160
from their sun their stars

1708
01:08:16,229 --> 01:08:13,839
if you've got tidal

1709
01:08:18,789 --> 01:08:16,239
interactions that is a source of heat

1710
01:08:21,269 --> 01:08:18,799
right and more energy flux

1711
01:08:23,269 --> 01:08:21,279
which can create surface habitable

1712
01:08:26,070 --> 01:08:23,279
conditions make planets or moons warm

1713
01:08:27,990 --> 01:08:26,080

enough for surface liquid water so

1714
01:08:29,910 --> 01:08:28,000
getting together with the sort of

1715
01:08:32,390 --> 01:08:29,920
geophysical communities and

1716
01:08:34,870 --> 01:08:32,400
incorporating more of this kind of

1717
01:08:38,070 --> 01:08:34,880
different geothermal heat fluxes and

1718
01:08:39,829 --> 01:08:38,080
seeing how that could input into

1719
01:08:40,950 --> 01:08:39,839
climate model results would be a

1720
01:08:42,149 --> 01:08:40,960
valuable

1721
01:08:45,030 --> 01:08:42,159
step

1722
01:08:47,430 --> 01:08:45,040
wonderful i think that is all of our

1723
01:08:51,990 --> 01:08:47,440
time so let's let's thank our keynote

1724
01:08:54,149 --> 01:08:52,000
speaker professor shields one more time

1725
01:08:55,910 --> 01:08:54,159
you so much it's been great

1726
01:08:58,550 --> 01:08:55,920
thank you so much

1727
01:09:00,470 --> 01:08:58,560
thank you everyone thank you dr shields

1728
01:09:03,030 --> 01:09:00,480
we will see you hopefully in person next

1729
01:09:04,630 --> 01:09:03,040
time thank you so much for being online

1730
01:09:06,870 --> 01:09:04,640
with us and giving that wonderful

1731
01:09:08,229 --> 01:09:06,880
inspiring talk and now for everyone in

1732
01:09:09,669 --> 01:09:08,239
the room you can go get coffee in the

1733
01:09:11,269 --> 01:09:09,679
reception and head out to your next