AbSciCon 2022

Crossing the Divides: Joint Earth History/Exoplanet/Solar System Research II

1
00:00:04,070 --> 00:00:02,070
to view our own solar system

2
00:00:06,150 --> 00:00:04,080
i'm eddie swederman from uc riverside

3
00:00:07,430 --> 00:00:06,160
i'm joined by my co-conveners dr

4
00:00:09,589 --> 00:00:07,440
victoria meadows from university of

5
00:00:11,270 --> 00:00:09,599
washington and dr stephanie olson from

6
00:00:12,950 --> 00:00:11,280
purdue university

7
00:00:14,230 --> 00:00:12,960
just some quick instructions for our

8
00:00:16,870 --> 00:00:14,240
speakers

9
00:00:18,390 --> 00:00:16,880
what we're going to do is have um a

10
00:00:20,390 --> 00:00:18,400
15-minute talks

11
00:00:21,670 --> 00:00:20,400
uh i'm going to be standing or sitting

12
00:00:23,590 --> 00:00:21,680
right here

13
00:00:25,269 --> 00:00:23,600

at 10 minutes i'll give you a two-minute

14
00:00:27,509 --> 00:00:25,279
warning and then we want three minutes

15
00:00:29,429 --> 00:00:27,519
for questions and change over and if you

16
00:00:31,750 --> 00:00:29,439
have questions please approach the mics

17
00:00:33,990 --> 00:00:31,760
uh in the um

18
00:00:35,430 --> 00:00:34,000
in these areas over here please

19
00:00:37,510 --> 00:00:35,440
and so i'd be happy i'm happy to

20
00:00:39,830 --> 00:00:37,520
introduce our first speaker uh carlos

21
00:00:41,430 --> 00:00:39,840
ortiz quintana who's going to talk about

22
00:00:43,430 --> 00:00:41,440
the mean global surface temperature of

23
00:00:45,430 --> 00:00:43,440
an earth-like planet derived from

24
00:00:48,950 --> 00:00:45,440
earth's

25
00:00:48,960 --> 00:00:59,270
thank you

26
00:01:04,549 --> 00:01:02,549
okay so um hi everyone um

27
00:01:05,750 --> 00:01:04,559
i'm carlos ortiz quintana and i come

28
00:01:07,990 --> 00:01:05,760
from the

29
00:01:10,710 --> 00:01:08,000
planetary habitability lab um located at

30
00:01:13,590 --> 00:01:10,720
the university of puerto rico at arecibo

31
00:01:15,830 --> 00:01:13,600
um i am professor abel mendez mentor who

32
00:01:18,870 --> 00:01:15,840
is the principal investigator at that

33
00:01:20,149 --> 00:01:18,880
lab um so my project is focused on the

34
00:01:21,270 --> 00:01:20,159
surface temperatures of earth-like

35
00:01:23,270 --> 00:01:21,280
planets

36
00:01:24,630 --> 00:01:23,280
and specifically we are trying to derive

37
00:01:26,630 --> 00:01:24,640
a model

38
00:01:28,149 --> 00:01:26,640

from the geological history of our own

39
00:01:30,630 --> 00:01:28,159
planet

40
00:01:33,109 --> 00:01:30,640
so um starting with our

41
00:01:34,230 --> 00:01:33,119
with the model itself um

42
00:01:36,630 --> 00:01:34,240
this

43
00:01:37,830 --> 00:01:36,640
equation corresponds to to a surface

44
00:01:40,550 --> 00:01:37,840
temperature

45
00:01:42,149 --> 00:01:40,560
equation which basically gives you

46
00:01:44,469 --> 00:01:42,159
the temperatures

47
00:01:46,950 --> 00:01:44,479
based on parameters such as the bon

48
00:01:48,789 --> 00:01:46,960
albedo the normalized greenhouse effect

49
00:01:52,310 --> 00:01:48,799
the stellar stellar luminosity and the

50
00:01:56,230 --> 00:01:52,320
semi-major axis um so this is a a result

51
00:01:57,990 --> 00:01:56,240
that was published um in 2017 and so um

52
00:01:59,910 --> 00:01:58,000
this has been around for some time

53
00:02:02,069 --> 00:01:59,920
already but what we're saying with this

54
00:02:05,270 --> 00:02:02,079
project is that this equation can be

55
00:02:06,950 --> 00:02:05,280
summarized in this expression over here

56
00:02:09,990 --> 00:02:06,960
so um kappa

57
00:02:12,630 --> 00:02:10,000
corresponds to a quantity a new quantity

58
00:02:14,869 --> 00:02:12,640
that we are defining as the thermality

59
00:02:17,430 --> 00:02:14,879
um and so it it is kind of like a

60
00:02:19,910 --> 00:02:17,440
convenient way of summarizing the

61
00:02:21,589 --> 00:02:19,920
effects of the bonalbito and the

62
00:02:22,630 --> 00:02:21,599
normalized greenhouse in the surface

63
00:02:24,470 --> 00:02:22,640

temperatures

64
00:02:27,910 --> 00:02:24,480
and that expression also includes the

65
00:02:28,869 --> 00:02:27,920
equilibrium temperature at zero albedo

66
00:02:30,949 --> 00:02:28,879
um from

67
00:02:32,470 --> 00:02:30,959
the parameters that we have here

68
00:02:35,430 --> 00:02:32,480
one of the most important ones that we

69
00:02:38,309 --> 00:02:35,440
want to study is the bon albedo and so

70
00:02:41,910 --> 00:02:38,319
um what we're proposing is um

71
00:02:43,589 --> 00:02:41,920
this equation of the bon albedo um which

72
00:02:46,070 --> 00:02:43,599
we are assuming a linear relation

73
00:02:50,550 --> 00:02:46,080
between the land to ocean fractions of

74
00:02:53,030 --> 00:02:50,560
the planet so essentially um it is a sum

75
00:02:56,309 --> 00:02:53,040
of the individual contributions of each

76
00:02:58,309 --> 00:02:56,319
surface um multiplied by the their

77
00:02:59,110 --> 00:02:58,319
respective nettle beetles

78
00:03:01,990 --> 00:02:59,120
um

79
00:03:05,110 --> 00:03:02,000
in this slide we also have a table that

80
00:03:06,790 --> 00:03:05,120
summarizes some of these parameters for

81
00:03:08,949 --> 00:03:06,800
the current earth

82
00:03:11,589 --> 00:03:08,959
so here what we have is the one albedo

83
00:03:13,190 --> 00:03:11,599
and the surface temperature

84
00:03:16,550 --> 00:03:13,200
and so

85
00:03:18,390 --> 00:03:16,560
these are values for the overall global

86
00:03:20,149 --> 00:03:18,400
parameters but we also have the

87
00:03:21,910 --> 00:03:20,159
individual contributions from land and

88
00:03:24,789 --> 00:03:21,920

oceans i mean based on all this

89
00:03:27,270 --> 00:03:24,799
information we can um compute the

90
00:03:28,630 --> 00:03:27,280
normalized greenhouse effect um which is

91
00:03:29,550 --> 00:03:28,640
um given

92
00:03:31,270 --> 00:03:29,560
by

93
00:03:34,390 --> 00:03:31,280
0.382

94
00:03:35,910 --> 00:03:34,400
and the thermal parameter which is the

95
00:03:38,229 --> 00:03:35,920
1.034

96
00:03:39,430 --> 00:03:38,239
that you see there

97
00:03:44,309 --> 00:03:39,440
um

98
00:03:47,030 --> 00:03:44,319
we want to study three main important

99
00:03:48,789 --> 00:03:47,040
parameters that are related to the

100
00:03:50,710 --> 00:03:48,799
surface temperatures of the planet the

101
00:03:53,110 --> 00:03:50,720
bon albedo the normalized greenhouse

102
00:03:55,190 --> 00:03:53,120
effect and the thermality which again is

103
00:03:57,270 --> 00:03:55,200
a new quantity that we're trying to

104
00:04:00,390 --> 00:03:57,280
introduce um

105
00:04:01,830 --> 00:04:00,400
these equations are

106
00:04:04,630 --> 00:04:01,840
the way that you calculate the

107
00:04:07,350 --> 00:04:04,640
greenhouse and the thermality and so

108
00:04:08,229 --> 00:04:07,360
they are given by the

109
00:04:11,990 --> 00:04:08,239
um

110
00:04:13,910 --> 00:04:12,000
temperature and the stellar flux and

111
00:04:16,390 --> 00:04:13,920
these are parameters that you can find

112
00:04:18,310 --> 00:04:16,400
or get from gcms for example um so the

113
00:04:21,189 --> 00:04:18,320

idea behind using these

114
00:04:23,510 --> 00:04:21,199
equations is to input the results from

115
00:04:25,670 --> 00:04:23,520
gcms into these

116
00:04:27,030 --> 00:04:25,680
parameters over here and so study the

117
00:04:29,110 --> 00:04:27,040
relationship that they have with the

118
00:04:31,830 --> 00:04:29,120
gcms

119
00:04:34,870 --> 00:04:31,840
this table over here summarizes some of

120
00:04:38,070 --> 00:04:34,880
these um volumes for the solar system so

121
00:04:39,430 --> 00:04:38,080
we have venus earth mars and titan

122
00:04:42,550 --> 00:04:39,440
um

123
00:04:45,110 --> 00:04:42,560
and it turns out that for the something

124
00:04:47,189 --> 00:04:45,120
that we find that that we found

125
00:04:50,310 --> 00:04:47,199
is that the thermality for earth mars

126
00:04:52,150 --> 00:04:50,320
and titan can be approximated what two

127
00:04:53,990 --> 00:04:52,160
to one um and so that's something

128
00:04:57,110 --> 00:04:54,000
interesting um

129
00:04:59,510 --> 00:04:57,120
for now um as of today we don't have an

130
00:05:00,710 --> 00:04:59,520
exact explain explanation for that um

131
00:05:04,629 --> 00:05:00,720
but that's one of the things that we

132
00:05:06,310 --> 00:05:04,639
want to um improve and study further um

133
00:05:08,550 --> 00:05:06,320
but compare that thermody to the

134
00:05:10,629 --> 00:05:08,560
thermality that we found for venus which

135
00:05:14,550 --> 00:05:10,639
is 2.2

136
00:05:16,390 --> 00:05:14,560
13. um so it is a great change um and

137
00:05:19,270 --> 00:05:16,400
that could be explained possibly by the

138
00:05:24,550 --> 00:05:19,280

higher temperatures of venus or even the

139
00:05:31,029 --> 00:05:28,310
um so for our focus um

140
00:05:33,990 --> 00:05:31,039
we are using the idea of the project is

141
00:05:37,510 --> 00:05:34,000
to use the different periods of earth

142
00:05:40,629 --> 00:05:37,520
as um different um exoplanets with

143
00:05:42,070 --> 00:05:40,639
similar properties as the current um

144
00:05:44,629 --> 00:05:42,080
period that we are

145
00:05:45,830 --> 00:05:44,639
um so for example here

146
00:05:47,830 --> 00:05:45,840
basically

147
00:05:49,830 --> 00:05:47,840
the earth of 300

148
00:05:52,150 --> 00:05:49,840
400 million years ago

149
00:05:53,990 --> 00:05:52,160
was a complete different world than the

150
00:05:56,550 --> 00:05:54,000
one that we have today

151
00:05:58,550 --> 00:05:56,560
so by using the differences in these

152
00:06:01,029 --> 00:05:58,560
parameters we can then

153
00:06:04,710 --> 00:06:01,039
study different conditions of exoplanets

154
00:06:09,830 --> 00:06:04,720
um so based on this idea and the changes

155
00:06:12,950 --> 00:06:09,840
in the fractions of land to ocean ratios

156
00:06:15,430 --> 00:06:12,960
we then um computed this equation over

157
00:06:17,590 --> 00:06:15,440
here which is the model that we proposed

158
00:06:18,950 --> 00:06:17,600
for the bone albedo

159
00:06:21,670 --> 00:06:18,960
so

160
00:06:27,110 --> 00:06:21,680
the this tell tell us that the net

161
00:06:31,670 --> 00:06:27,120
albedo of the land um is 0.4 a 19 well

162
00:06:37,430 --> 00:06:35,110
um by applying that model to the surface

163
00:06:40,469 --> 00:06:37,440

temperature model that we had already um

164
00:06:42,390 --> 00:06:40,479
we oh and assuming a constant greenhouse

165
00:06:46,150 --> 00:06:42,400
of 0.4

166
00:06:48,390 --> 00:06:46,160
um we were able to compute this um blue

167
00:06:50,150 --> 00:06:48,400
curve that would you observe in the plot

168
00:06:53,189 --> 00:06:50,160
over there

169
00:06:55,749 --> 00:06:53,199
again this was computed by assuming a

170
00:06:57,189 --> 00:06:55,759
constant greenhouse um and this helped

171
00:06:59,589 --> 00:06:57,199
us

172
00:07:02,629 --> 00:06:59,599
find or study the the individual

173
00:07:05,990 --> 00:07:02,639
contribution of the changes of land to

174
00:07:08,870 --> 00:07:06,000
ocean fractions um and that those

175
00:07:10,629 --> 00:07:08,880
contributions were about um two degrees

176
00:07:12,390 --> 00:07:10,639
celsius

177
00:07:14,550 --> 00:07:12,400
of change in the current mean global

178
00:07:18,629 --> 00:07:14,560
temperatures

179
00:07:21,350 --> 00:07:18,639
um the this uh the in this plot we also

180
00:07:23,589 --> 00:07:21,360
compare the evolution or changes in the

181
00:07:27,029 --> 00:07:23,599
temperatures um for two different

182
00:07:28,790 --> 00:07:27,039
proxies um so um for example ryder and

183
00:07:30,629 --> 00:07:28,800
scott s um

184
00:07:33,189 --> 00:07:30,639
and so

185
00:07:34,150 --> 00:07:33,199
it is important to note there that you

186
00:07:36,230 --> 00:07:34,160
observe

187
00:07:39,270 --> 00:07:36,240
differences a lot of of great

188
00:07:41,830 --> 00:07:39,280

differences between our curve and the um

189
00:07:42,830 --> 00:07:41,840
the changes in the in the in the proxies

190
00:07:46,309 --> 00:07:42,840
so we are

191
00:07:47,909 --> 00:07:46,319
um attributing the remaining effect of

192
00:07:49,670 --> 00:07:47,919
the changes in temperatures to the

193
00:07:53,510 --> 00:07:49,680
greenhouse um so

194
00:07:55,990 --> 00:07:53,520
um applying our model to those um

195
00:07:57,830 --> 00:07:56,000
proxies we were able to correct um for

196
00:08:00,790 --> 00:07:57,840
those greenhouses and obtain the

197
00:08:03,430 --> 00:08:00,800
evolution of the greenhouse for example

198
00:08:06,150 --> 00:08:03,440
during the the thunderous wake um which

199
00:08:08,869 --> 00:08:06,160
by the way those proxies are um defined

200
00:08:12,629 --> 00:08:08,879
for the f phanerozoic um which is

201
00:08:15,909 --> 00:08:12,639
roughly 550 million years ago

202
00:08:18,230 --> 00:08:15,919
um and this in the these curves um tell

203
00:08:20,629 --> 00:08:18,240
us a range um

204
00:08:21,430 --> 00:08:20,639
for the greenhouse between the finance

205
00:08:25,350 --> 00:08:21,440
work

206
00:08:27,189 --> 00:08:25,360
and so the range um can be between 0.37

207
00:08:30,469 --> 00:08:27,199
to 0.47

208
00:08:33,190 --> 00:08:30,479
um this is the normalized greenhouse

209
00:08:35,909 --> 00:08:33,200
um and so this is one of the

210
00:08:40,790 --> 00:08:35,919
important um results of our project

211
00:08:43,190 --> 00:08:40,800
because again by assuming or studying

212
00:08:45,990 --> 00:08:43,200
the different periods of earth as

213
00:08:49,509 --> 00:08:46,000

exoplanets then on that range can be

214
00:08:51,430 --> 00:08:49,519
used to study possible um greenhouse

215
00:08:53,509 --> 00:08:51,440
ranges to sustain

216
00:08:56,150 --> 00:08:53,519
surface temperatures of earth-like

217
00:08:59,990 --> 00:08:59,030
and the in in this this model also

218
00:09:01,110 --> 00:09:00,000
predicts

219
00:09:07,590 --> 00:09:01,120
um

220
00:09:10,150 --> 00:09:07,600
suite we did the same thing for the

221
00:09:11,070 --> 00:09:10,160
thermality um and so we found a range

222
00:09:14,790 --> 00:09:11,080
between

223
00:09:17,350 --> 00:09:14,800
1.035 and 1.080 for the thermality

224
00:09:19,990 --> 00:09:17,360
during the entire funeral soic

225
00:09:21,269 --> 00:09:20,000
and again this can be used for

226
00:09:22,949 --> 00:09:21,279
to study

227
00:09:26,550 --> 00:09:22,959
exoplanets

228
00:09:30,389 --> 00:09:26,560
to sustain temperatures um similar to

229
00:09:35,269 --> 00:09:33,190
so an example of an application that we

230
00:09:38,550 --> 00:09:35,279
can do with this model

231
00:09:42,230 --> 00:09:38,560
is the tropis1 system so that equation

232
00:09:42,949 --> 00:09:42,240
that you observe here is um

233
00:09:53,030 --> 00:09:42,959
the

234
00:09:55,430 --> 00:09:53,040
for thin to thick dry uh carbon dioxide

235
00:09:57,910 --> 00:09:55,440
atmosphere so basically atmospheres uh

236
00:09:59,590 --> 00:09:57,920
made of of carbon dioxides with less

237
00:10:01,120 --> 00:09:59,600
than ten bars

238
00:10:03,269 --> 00:10:01,130

um and so the the

239
00:10:06,870 --> 00:10:03,279
[Music]

240
00:10:08,509 --> 00:10:06,880
the thermality for these systems um was

241
00:10:11,269 --> 00:10:08,519
or is

242
00:10:12,230 --> 00:10:11,279
1.107 according to our model

243
00:10:13,190 --> 00:10:12,240
um

244
00:10:14,710 --> 00:10:13,200
and so

245
00:10:17,190 --> 00:10:14,720
uh these temperatures that you observe

246
00:10:20,230 --> 00:10:17,200
in here are the ones that we computed

247
00:10:22,790 --> 00:10:20,240
for using our our model so based on on

248
00:10:25,430 --> 00:10:22,800
our model what we can say is that for

249
00:10:28,949 --> 00:10:25,440
example for planets pc

250
00:10:31,509 --> 00:10:28,959
um g and h they are less likely to

251
00:10:34,069 --> 00:10:31,519
sustain temperatures similar to

252
00:10:35,430 --> 00:10:34,079
what we have on earth meaning 0 to 50

253
00:10:37,990 --> 00:10:35,440
degrees celsius

254
00:10:41,590 --> 00:10:38,000
but for in the in the case of planets d

255
00:10:43,750 --> 00:10:41,600
e and even f they are more likely to

256
00:10:47,350 --> 00:10:43,760
to sustain those planets those

257
00:10:49,750 --> 00:10:48,389
um so

258
00:10:53,990 --> 00:10:49,760
in conclusion

259
00:10:59,990 --> 00:10:57,829
define a range of the greenhouse for

260
00:11:02,870 --> 00:11:00,000
earth-like planets with similar stiller

261
00:11:05,750 --> 00:11:02,880
flux and similar atmospheres and that

262
00:11:07,430 --> 00:11:05,760
range is 0.3 to 0.5

263
00:11:08,630 --> 00:11:07,440

and that is to support temperate

264
00:11:10,870 --> 00:11:08,640
temperatures

265
00:11:12,389 --> 00:11:10,880
between these zero degrees celsius to 50

266
00:11:14,470 --> 00:11:12,399
degrees celsius i mean that's very

267
00:11:17,590 --> 00:11:14,480
important because those are the limits

268
00:11:19,670 --> 00:11:17,600
of life that we know so far

269
00:11:21,750 --> 00:11:19,680
um our work also provides a simple

270
00:11:24,150 --> 00:11:21,760
empirical model um calibrated with

271
00:11:26,550 --> 00:11:24,160
terrestrial pile temperatures to

272
00:11:28,069 --> 00:11:26,560
quantify the combined dependency of land

273
00:11:30,790 --> 00:11:28,079
to ocean fraction and greenhouse in

274
00:11:32,470 --> 00:11:30,800
temperature earth-like planets um and so

275
00:11:34,310 --> 00:11:32,480
those two equations that you see there

276
00:11:35,509 --> 00:11:34,320
it's one of the main takeaway points of

277
00:11:37,990 --> 00:11:35,519
this talk

278
00:11:40,470 --> 00:11:38,000
um this is the the surface temperature

279
00:11:42,710 --> 00:11:40,480
model um and the other one is the one

280
00:11:45,509 --> 00:11:42,720
albedo equation

281
00:11:48,710 --> 00:11:45,519
and so our model can be used to test or

282
00:11:50,710 --> 00:11:48,720
validate results from gcms or even

283
00:11:53,670 --> 00:11:50,720
constrain exoplanet surface temperatures

284
00:11:57,110 --> 00:11:53,680
from observations

285
00:11:59,590 --> 00:11:57,120
um so for additional work um we want to

286
00:12:02,550 --> 00:11:59,600
derive a more more complete

287
00:12:05,350 --> 00:12:02,560
model for the albedo that could include

288
00:12:06,790 --> 00:12:05,360

all of the different surfaces um for

289
00:12:10,310 --> 00:12:06,800
compensating for different surface

290
00:12:12,069 --> 00:12:10,320
properties so for example um ice

291
00:12:13,350 --> 00:12:12,079
vegetation and even deserts and that's

292
00:12:15,269 --> 00:12:13,360
important because

293
00:12:18,230 --> 00:12:15,279
different exoplanets will have different

294
00:12:21,190 --> 00:12:18,240
types of surfaces and we also want to

295
00:12:22,829 --> 00:12:21,200
compare our model with results from dcms

296
00:12:26,389 --> 00:12:22,839
for example rocky

297
00:12:29,910 --> 00:12:26,399
3d um we we want to

298
00:12:32,150 --> 00:12:29,920
apply our model to the x to x potential

299
00:12:34,310 --> 00:12:32,160
exoplanet surfaces such as tropis one

300
00:12:36,710 --> 00:12:34,320
that we um i already presented some of

301
00:12:39,110 --> 00:12:36,720
the results that we have so far but we

302
00:12:41,430 --> 00:12:39,120
want to to improve that and

303
00:12:43,030 --> 00:12:41,440
test different conditions for for those

304
00:12:45,590 --> 00:12:43,040
planets

305
00:12:48,470 --> 00:12:45,600
i mean we also want to use this work to

306
00:12:52,389 --> 00:12:48,480
try and characterize a circumstellar

307
00:12:55,430 --> 00:12:52,399
tempered temperature zone um which in

308
00:12:57,509 --> 00:12:55,440
other words it's just trying to to study

309
00:13:00,550 --> 00:12:57,519
a zone um for

310
00:13:02,389 --> 00:13:00,560
planets that have um temperatures from

311
00:13:06,230 --> 00:13:02,399
zero degrees celsius to 50 degrees

312
00:13:09,269 --> 00:13:06,240
celsius um and i would like to thank my

313
00:13:10,040 --> 00:13:09,279

um advisor um abel mendez

314
00:13:11,829 --> 00:13:10,050
and the

315
00:13:14,310 --> 00:13:11,839
[Music]

316
00:13:17,269 --> 00:13:14,320
nasa puerto rico space grant which were

317
00:13:18,230 --> 00:13:17,279
the ones that funded me for this project

318
00:13:19,590 --> 00:13:18,240
um

319
00:13:29,670 --> 00:13:19,600
so that will be oh and thanks for your

320
00:13:35,990 --> 00:13:31,670
those with questions please uh raise

321
00:13:38,710 --> 00:13:37,750
introduce yourself and your affiliation

322
00:13:40,949 --> 00:13:38,720
yes

323
00:13:42,629 --> 00:13:40,959
from edh uh

324
00:13:44,550 --> 00:13:42,639
maybe a naive question i don't know can

325
00:13:47,430 --> 00:13:44,560
you go back to the

326
00:13:49,990 --> 00:13:47,440
previous slide great yeah so say that we

327
00:13:52,150 --> 00:13:50,000
detect well we have an estimate of the

328
00:13:54,550 --> 00:13:52,160
surface temperature with future

329
00:13:55,670 --> 00:13:54,560
emissions talking about 20 years from

330
00:13:58,230 --> 00:13:55,680
now

331
00:14:00,389 --> 00:13:58,240
could you at that point get an estimate

332
00:14:02,629 --> 00:14:00,399
of the fraction of land versus a

333
00:14:04,550 --> 00:14:02,639
fraction of water or is it totally

334
00:14:07,110 --> 00:14:04,560
unfeasible

335
00:14:08,150 --> 00:14:07,120
um i think that potentially we could

336
00:14:09,110 --> 00:14:08,160
um

337
00:14:11,590 --> 00:14:09,120
because

338
00:14:13,910 --> 00:14:11,600

um by if if you know the normalized

339
00:14:17,189 --> 00:14:13,920
greenhouse effect for example um you

340
00:14:19,910 --> 00:14:17,199
will essentially um and if you estimate

341
00:14:22,629 --> 00:14:19,920
the surface temperature you will eventu

342
00:14:24,949 --> 00:14:22,639
eventually find the bon albedo and so by

343
00:14:26,389 --> 00:14:24,959
finding the bon alberto you could um get

344
00:14:39,030 --> 00:14:26,399
the

345
00:14:42,230 --> 00:14:39,040
if not i've got one quick question which

346
00:14:43,509 --> 00:14:42,240
is uh how do you account for clouds

347
00:14:49,110 --> 00:14:43,519
um

348
00:14:51,590 --> 00:14:49,120
consider the the

349
00:14:53,829 --> 00:14:51,600
the the clouds well the

350
00:14:56,629 --> 00:14:53,839
those nettle beetles possibly have some

351
00:15:00,389 --> 00:14:56,639
contribution of clouds at least in the

352
00:15:02,629 --> 00:15:00,399
in the in the lan albedo um but directly

353
00:15:04,389 --> 00:15:02,639
we are not considering that that's one

354
00:15:14,629 --> 00:15:04,399
of the possibilities to consider for the

355
00:15:18,550 --> 00:15:17,350
all right so

356
00:15:23,509 --> 00:15:18,560
oh

357
00:15:30,389 --> 00:15:27,750
no i didn't see it a phone

358
00:15:32,710 --> 00:15:30,399
okay um our next presenter uh will be

359
00:15:34,069 --> 00:15:32,720
tim live and good

360
00:15:37,749 --> 00:15:34,079
and let's hope your

361
00:15:41,030 --> 00:15:38,629
okay

362
00:15:42,790 --> 00:15:41,040
who will be now talking to us about a

363
00:15:44,870 --> 00:15:42,800

comparison of the earth poles and signs

364
00:15:47,269 --> 00:15:44,880
of habitability although i can see it

365
00:15:49,030 --> 00:15:47,279
here can we see it on the screens here

366
00:15:56,790 --> 00:15:49,040
yes okay we can't see it here on the

367
00:16:01,030 --> 00:15:58,389
oh there we go here we are we're finally

368
00:16:04,230 --> 00:16:01,040
loaded okay all right

369
00:16:05,749 --> 00:16:04,240
there you go all righty

370
00:16:10,949 --> 00:16:05,759
keep your distance on becoming a

371
00:16:16,629 --> 00:16:14,389
all right um good afternoon i spoke this

372
00:16:17,430 --> 00:16:16,639
morning presenting uh roderick decox

373
00:16:21,030 --> 00:16:17,440
work

374
00:16:24,069 --> 00:16:21,040
on looking at the there it is

375
00:16:26,230 --> 00:16:24,079
of the phase variation of visible light

376
00:16:28,629 --> 00:16:26,240
signal from the earth uh and now i'm

377
00:16:31,990 --> 00:16:28,639
going to give more of a general overview

378
00:16:34,389 --> 00:16:32,000
of the polar observations that were

379
00:16:36,550 --> 00:16:34,399
a part of that work

380
00:16:38,629 --> 00:16:36,560
uh what you're looking at there are the

381
00:16:41,509 --> 00:16:38,639
uh the time average north and south

382
00:16:44,470 --> 00:16:41,519
polar images uh that we built up from

383
00:16:46,710 --> 00:16:44,480
24-hour observations of of each of them

384
00:16:48,230 --> 00:16:46,720
north is on the left south is on the

385
00:16:52,470 --> 00:16:48,240
right

386
00:16:55,030 --> 00:16:52,480
uh this results from the uh the epoxy

387
00:16:58,310 --> 00:16:55,040
extended mission of the deep impact

388
00:17:00,629 --> 00:16:58,320

spacecraft epoxy is a pun

389
00:17:02,949 --> 00:17:00,639
on uh extrasolar planet observation and

390
00:17:05,270 --> 00:17:02,959
characterization mixed with the deep

391
00:17:07,029 --> 00:17:05,280
impact extended investigation

392
00:17:08,549 --> 00:17:07,039
after nasa headquarters told us so we

393
00:17:10,069 --> 00:17:08,559
could do both but we had to do it on the

394
00:17:11,990 --> 00:17:10,079
budget of one of them

395
00:17:15,270 --> 00:17:12,000
that was and then they cut that budget

396
00:17:17,029 --> 00:17:15,280
but anyway uh so we made uh the earth

397
00:17:20,390 --> 00:17:17,039
observations we had five planned

398
00:17:22,549 --> 00:17:20,400
observations in 2008 in march through

399
00:17:24,470 --> 00:17:22,559
june uh observations number two and

400
00:17:27,029 --> 00:17:24,480
three were cancelled which leads to the

401
00:17:30,150 --> 00:17:27,039
weird nomenclature that you'll see

402
00:17:32,549 --> 00:17:30,160
and then we followed up in 2009 with

403
00:17:34,710 --> 00:17:32,559
makeup observations for those two lost

404
00:17:36,789 --> 00:17:34,720
ones from 2008

405
00:17:38,950 --> 00:17:36,799
that happened because of the orbit the

406
00:17:41,110 --> 00:17:38,960
spacecraft was following to eventually

407
00:17:43,510 --> 00:17:41,120
get to comet hartley 2

408
00:17:45,430 --> 00:17:43,520
to be able to observe the earth at very

409
00:17:47,590 --> 00:17:45,440
high latitudes so we were able to do

410
00:17:48,870 --> 00:17:47,600
each of the north and south and

411
00:17:50,710 --> 00:17:48,880
for no

412
00:17:53,190 --> 00:17:50,720
special reason they ended up in both

413
00:17:54,470 --> 00:17:53,200

cases being at the respective vernal

414
00:17:56,630 --> 00:17:54,480
equinox

415
00:17:58,630 --> 00:17:56,640
but that does affect any conclusions

416
00:17:59,510 --> 00:17:58,640
might be related to seasonality of the

417
00:18:01,430 --> 00:17:59,520
earth

418
00:18:03,430 --> 00:18:01,440
that you might be observing there

419
00:18:06,470 --> 00:18:03,440
the instruments we use there's a visible

420
00:18:08,789 --> 00:18:06,480
camera uh with seven different filters

421
00:18:10,310 --> 00:18:08,799
um 100 nanometer bandwidth each

422
00:18:12,150 --> 00:18:10,320
nominally

423
00:18:15,350 --> 00:18:12,160
with some limits at either end due to

424
00:18:17,270 --> 00:18:15,360
the restrictions of ccd technology

425
00:18:21,110 --> 00:18:17,280
uh and spaced

426
00:18:23,669 --> 00:18:21,120
every uh every 100 nanometers on the 50s

427
00:18:25,190 --> 00:18:23,679
and a near infrared spectrometer

428
00:18:28,150 --> 00:18:25,200
operating from

429
00:18:29,590 --> 00:18:28,160
just over one micron to a little under 5

430
00:18:30,789 --> 00:18:29,600
micron

431
00:18:35,350 --> 00:18:30,799
all right

432
00:18:39,830 --> 00:18:38,230
i don't think that's me making ah okay

433
00:18:42,390 --> 00:18:39,840
so

434
00:18:44,870 --> 00:18:42,400
we previously published the equatorial

435
00:18:46,310 --> 00:18:44,880
observations a long time ago back in

436
00:18:48,789 --> 00:18:46,320
2011

437
00:18:50,470 --> 00:18:48,799
uh showing the the three that were uh

438
00:18:52,630 --> 00:18:50,480

conducted then and you can see we we

439
00:18:53,909 --> 00:18:52,640
were in astrobiology we got the cover

440
00:18:56,230 --> 00:18:53,919
man

441
00:18:59,270 --> 00:18:56,240
showing among other things we had this

442
00:19:01,190 --> 00:18:59,280
very nifty observation with the moon

443
00:19:02,870 --> 00:19:01,200
actually transiting the earth during our

444
00:19:05,430 --> 00:19:02,880
observations so that we could see the

445
00:19:07,350 --> 00:19:05,440
effect of an exomoon on the light curve

446
00:19:08,870 --> 00:19:07,360
of the individual planet that's not

447
00:19:10,630 --> 00:19:08,880
something you would normally

448
00:19:12,950 --> 00:19:10,640
expect to be able to capture for an

449
00:19:14,950 --> 00:19:12,960
exoplanet because the

450
00:19:15,990 --> 00:19:14,960
if you have to assemble your data over

451
00:19:17,430 --> 00:19:16,000
months

452
00:19:19,669 --> 00:19:17,440
you're not going to be able to get you

453
00:19:21,029 --> 00:19:19,679
know to organize those individual events

454
00:19:22,830 --> 00:19:21,039
but it was good to know how much of an

455
00:19:24,549 --> 00:19:22,840
effect it had

456
00:19:25,350 --> 00:19:24,559
spectroscopically

457
00:19:27,029 --> 00:19:25,360
uh

458
00:19:28,549 --> 00:19:27,039
the moon and the earth are very

459
00:19:30,070 --> 00:19:28,559
different due to the fact that one of

460
00:19:33,350 --> 00:19:30,080
them has an atmosphere

461
00:19:35,190 --> 00:19:33,360
um although uh surprisingly at the time

462
00:19:37,750 --> 00:19:35,200
that i collected the data i didn't

463
00:19:39,590 --> 00:19:37,760

understand it because it's not doing uh

464
00:19:42,230 --> 00:19:39,600
you know spectra of rocks in space is

465
00:19:45,190 --> 00:19:42,240
not my thing but you can now clearly see

466
00:19:46,310 --> 00:19:45,200
the 2.8 micron hydration absorption in

467
00:19:49,029 --> 00:19:46,320
the moon

468
00:19:51,270 --> 00:19:49,039
which was identified after we had gotten

469
00:19:52,710 --> 00:19:51,280
this it's like dang

470
00:19:55,190 --> 00:19:52,720
i didn't know

471
00:19:57,830 --> 00:19:55,200
uh you can also see we fit the long

472
00:19:59,990 --> 00:19:57,840
wavelength end to get an effective color

473
00:20:02,549 --> 00:20:00,000
temperature uh for both the earth and

474
00:20:05,430 --> 00:20:02,559
the moon uh that was actually in in

475
00:20:07,990 --> 00:20:05,440
reasonable you know approximation for

476
00:20:09,830 --> 00:20:08,000
the emergent spectrum of each planet the

477
00:20:11,909 --> 00:20:09,840
polar observations came out a little bit

478
00:20:13,830 --> 00:20:11,919
differently

479
00:20:15,350 --> 00:20:13,840
i had to change the scale the figure

480
00:20:17,669 --> 00:20:15,360
otherwise they would have

481
00:20:20,390 --> 00:20:17,679
completely covered the entire thing

482
00:20:22,789 --> 00:20:20,400
the relative scale of the images is

483
00:20:24,710 --> 00:20:22,799
correct we were much closer when we

484
00:20:26,549 --> 00:20:24,720
observed the poles than we were when we

485
00:20:29,270 --> 00:20:26,559
observed the equator

486
00:20:30,230 --> 00:20:29,280
and so you just so you'll know the color

487
00:20:32,630 --> 00:20:30,240
map

488
00:20:36,070 --> 00:20:32,640

that we chose for this the red fill or

489
00:20:37,110 --> 00:20:36,080
the red image in the color images is

490
00:20:39,590 --> 00:20:37,120
actually

491
00:20:42,390 --> 00:20:39,600
the differential index between the

492
00:20:45,110 --> 00:20:42,400
near-infrared and red filters which is

493
00:20:47,029 --> 00:20:45,120
why uh southern africa is so nice and

494
00:20:49,590 --> 00:20:47,039
bright and red there to show you where

495
00:20:52,470 --> 00:20:49,600
all the plant life is

496
00:20:54,789 --> 00:20:52,480
the spectra of the

497
00:20:56,549 --> 00:20:54,799
polar regions and the

498
00:20:58,950 --> 00:20:56,559
i use the the first of our earth

499
00:21:01,430 --> 00:20:58,960
observations to compare here uh are

500
00:21:03,830 --> 00:21:01,440
noticeably different but primarily due

501
00:21:05,669 --> 00:21:03,840
to the just the difference in the total

502
00:21:08,470 --> 00:21:05,679
illuminated surface

503
00:21:10,549 --> 00:21:08,480
of the earth we did however get a

504
00:21:13,190 --> 00:21:10,559
different color temperature the

505
00:21:15,909 --> 00:21:13,200
brightness temperature of the

506
00:21:16,950 --> 00:21:15,919
polar observations is significantly less

507
00:21:18,310 --> 00:21:16,960
than

508
00:21:20,950 --> 00:21:18,320
the brightness temperature of the

509
00:21:22,070 --> 00:21:20,960
equatorial observation but the color

510
00:21:24,549 --> 00:21:22,080
temperature

511
00:21:27,669 --> 00:21:24,559
uh is noticeably greater

512
00:21:30,070 --> 00:21:27,679
than the color temperature of the

513
00:21:31,669 --> 00:21:30,080

of the other observations and i have to

514
00:21:34,390 --> 00:21:31,679
examine that a little bit to make sure

515
00:21:36,310 --> 00:21:34,400
that there's really meaningful physics

516
00:21:39,029 --> 00:21:36,320
in that as opposed to i just chose the

517
00:21:42,149 --> 00:21:39,039
wrong interval in or on which to fit

518
00:21:45,430 --> 00:21:42,159
i've also compared a bunch of

519
00:21:48,310 --> 00:21:45,440
reflection spectra from the usgs library

520
00:21:51,190 --> 00:21:48,320
uh to show how they do or fail to

521
00:21:53,990 --> 00:21:51,200
uh relate to the spectral features that

522
00:21:56,149 --> 00:21:54,000
are in the uh in the at the observed

523
00:21:59,029 --> 00:21:56,159
spectra so for instance you can see the

524
00:22:00,710 --> 00:21:59,039
big water absorption bands in lawn grass

525
00:22:03,270 --> 00:22:00,720
which doesn't cover the whole world but

526
00:22:04,630 --> 00:22:03,280
it it does cover my backyard

527
00:22:07,149 --> 00:22:04,640
uh

528
00:22:09,430 --> 00:22:07,159
to show a little more on how the

529
00:22:11,350 --> 00:22:09,440
spectrophotometry of the images works

530
00:22:13,270 --> 00:22:11,360
out in each of these i've got a

531
00:22:15,590 --> 00:22:13,280
simulated visible light image

532
00:22:17,190 --> 00:22:15,600
constructed from the different filters

533
00:22:20,070 --> 00:22:17,200
that we employed

534
00:22:21,270 --> 00:22:20,080
and on the right hand side is that

535
00:22:23,190 --> 00:22:21,280
that

536
00:22:25,909 --> 00:22:23,200
differential vegetation index

537
00:22:28,310 --> 00:22:25,919
measurement combined with green and blue

538
00:22:30,149 --> 00:22:28,320

to show you where all the plant life is

539
00:22:32,549 --> 00:22:30,159
and if you look down at the bottom edge

540
00:22:33,830 --> 00:22:32,559
for the 24 hour average in each case you

541
00:22:35,909 --> 00:22:33,840
can see

542
00:22:38,390 --> 00:22:35,919
some of the important contributors to

543
00:22:41,350 --> 00:22:38,400
what you would observe if you were an

544
00:22:43,430 --> 00:22:41,360
alien observing from our north polar

545
00:22:46,390 --> 00:22:43,440
region versus observing from our south

546
00:22:47,990 --> 00:22:46,400
pole versus observing from our equator

547
00:22:50,470 --> 00:22:48,000
so you can see in the left-hand side

548
00:22:52,149 --> 00:22:50,480
which shows the equatorial observations

549
00:22:54,630 --> 00:22:52,159
that the fact that the northern

550
00:22:56,950 --> 00:22:54,640
hemisphere is substantially redder than

551
00:22:58,070 --> 00:22:56,960
the southern hemisphere in this color

552
00:23:01,029 --> 00:22:58,080
map

553
00:23:03,430 --> 00:23:01,039
is indicating the existence of

554
00:23:05,430 --> 00:23:03,440
much more continental land mass with

555
00:23:08,310 --> 00:23:05,440
plant life on it

556
00:23:10,549 --> 00:23:08,320
that appears in in those images and so

557
00:23:12,310 --> 00:23:10,559
when you see that in the middle set

558
00:23:14,710 --> 00:23:12,320
which is looking at the north polar

559
00:23:17,350 --> 00:23:14,720
region you can clearly see that that

560
00:23:19,350 --> 00:23:17,360
nice pink polar cap region and that's

561
00:23:22,549 --> 00:23:19,360
due to the fact that asia and north

562
00:23:24,549 --> 00:23:22,559
america just completely dominate uh the

563
00:23:27,430 --> 00:23:24,559

land mass that's available to see

564
00:23:28,149 --> 00:23:27,440
whereas in the south polar one

565
00:23:30,470 --> 00:23:28,159
uh

566
00:23:31,590 --> 00:23:30,480
the tip of south america the tip of

567
00:23:34,070 --> 00:23:31,600
africa

568
00:23:36,390 --> 00:23:34,080
and a little bit of australia can be

569
00:23:38,789 --> 00:23:36,400
seen in the individual frames there's 96

570
00:23:40,470 --> 00:23:38,799
frames if you want i can you can come to

571
00:23:43,029 --> 00:23:40,480
me later on i can show you the movies

572
00:23:44,710 --> 00:23:43,039
they are cool to look at

573
00:23:46,310 --> 00:23:44,720
but it's much bluer

574
00:23:48,390 --> 00:23:46,320
in those south polar ones because

575
00:23:50,710 --> 00:23:48,400
there's very little land mass

576
00:23:51,590 --> 00:23:50,720
contributing to what is possible to see

577
00:23:53,350 --> 00:23:51,600
and so

578
00:23:57,190 --> 00:23:53,360
if you were for instance looking for

579
00:23:59,110 --> 00:23:57,200
something like the vegetation red edge

580
00:24:01,029 --> 00:23:59,120
the earth you would see from the south

581
00:24:02,390 --> 00:24:01,039
pole would be significantly different

582
00:24:03,590 --> 00:24:02,400
from the earth you would see from the

583
00:24:05,350 --> 00:24:03,600
north pole

584
00:24:06,870 --> 00:24:05,360
and you might draw different conclusions

585
00:24:08,789 --> 00:24:06,880
as to how much plant life there would be

586
00:24:09,909 --> 00:24:08,799
on earth if you were using just that

587
00:24:11,990 --> 00:24:09,919
property

588
00:24:15,190 --> 00:24:12,000

along with the fact that as it happens

589
00:24:18,710 --> 00:24:15,200
the spectral slope of lunar regolith is

590
00:24:20,710 --> 00:24:18,720
so steep that the standard differential

591
00:24:23,190 --> 00:24:20,720
vegetation index makes the moon look

592
00:24:28,070 --> 00:24:23,200
green and verdant uh by comparison to

593
00:24:30,310 --> 00:24:28,080
the earth so it's it's a limited tool

594
00:24:32,390 --> 00:24:30,320
a little bit more just showing the the

595
00:24:35,269 --> 00:24:32,400
near-infrared spectra are actually i've

596
00:24:37,430 --> 00:24:35,279
combined the spectrophotometry with the

597
00:24:39,190 --> 00:24:37,440
reflected near-infrared spectrum on the

598
00:24:40,310 --> 00:24:39,200
left and then we have the thermal

599
00:24:43,430 --> 00:24:40,320
emission

600
00:24:45,510 --> 00:24:43,440
is over on the right also indicating a

601
00:24:47,269 --> 00:24:45,520
number of different molecular species

602
00:24:49,269 --> 00:24:47,279
that contribute to what we see of course

603
00:24:50,870 --> 00:24:49,279
there's a lot more molecular species

604
00:24:52,950 --> 00:24:50,880
than that in the earth's atmosphere but

605
00:24:55,510 --> 00:24:52,960
the ones that make a measurement that

606
00:24:58,950 --> 00:24:55,520
you can plainly see with your eyeball

607
00:25:01,750 --> 00:24:58,960
are the ones that i've indicated here

608
00:25:03,750 --> 00:25:01,760
uh let's see just a last little bit a

609
00:25:06,630 --> 00:25:03,760
little bit more about the vegetation red

610
00:25:08,310 --> 00:25:06,640
edge there that i i've indicated the uh

611
00:25:10,230 --> 00:25:08,320
the filters that we would compare to

612
00:25:11,590 --> 00:25:10,240
each other in order to uh to make that

613
00:25:14,149 --> 00:25:11,600

calculation

614
00:25:16,950 --> 00:25:14,159
with the polar observations on the right

615
00:25:18,630 --> 00:25:16,960
compared with equatorial earth 1 and

616
00:25:20,710 --> 00:25:18,640
then just the equatorial earth

617
00:25:22,789 --> 00:25:20,720
observations on the left

618
00:25:25,190 --> 00:25:22,799
just to show that again it's it's a

619
00:25:27,350 --> 00:25:25,200
potentially misleading measure if you're

620
00:25:28,470 --> 00:25:27,360
going to try to use that the the deepest

621
00:25:30,470 --> 00:25:28,480
absorption

622
00:25:33,350 --> 00:25:30,480
in the earth's visible spectrum is at

623
00:25:35,350 --> 00:25:33,360
that 650 nanometer region which happens

624
00:25:38,789 --> 00:25:35,360
to also be where you have the deepest

625
00:25:40,549 --> 00:25:38,799
absorption of the visible ozone band

626
00:25:42,070 --> 00:25:40,559
so there are some real challenges there

627
00:25:44,149 --> 00:25:42,080
with trying to get visible light

628
00:25:45,669 --> 00:25:44,159
information to describe the earth the

629
00:25:47,110 --> 00:25:45,679
thing that's really distinctive about

630
00:25:49,830 --> 00:25:47,120
the earth compared to all the rest of

631
00:25:51,669 --> 00:25:49,840
the solar system is the uh the strong

632
00:25:53,590 --> 00:25:51,679
rayleigh scattering at short wavelength

633
00:25:55,430 --> 00:25:53,600
where the earth is really bright the

634
00:25:59,110 --> 00:25:55,440
earth is the only object in the solar

635
00:26:01,669 --> 00:25:59,120
system it turns out that is at present

636
00:26:03,590 --> 00:26:01,679
very blue and also very red there are

637
00:26:05,190 --> 00:26:03,600
some that are one or the other of those

638
00:26:07,990 --> 00:26:05,200

properties but earth is the only one

639
00:26:09,909 --> 00:26:08,000
that combines them

640
00:26:11,830 --> 00:26:09,919
last bit this is something that you may

641
00:26:13,750 --> 00:26:11,840
have seen in roderick decox

642
00:26:16,950 --> 00:26:13,760
uh talk this morning that i showed you

643
00:26:19,590 --> 00:26:16,960
but just a reminder that the

644
00:26:22,630 --> 00:26:19,600
the polar observations of the earth have

645
00:26:25,190 --> 00:26:22,640
a much higher okay a noticeably higher

646
00:26:27,909 --> 00:26:25,200
uh albedo and if you

647
00:26:30,549 --> 00:26:27,919
were to try to model them with a uh

648
00:26:32,390 --> 00:26:30,559
lambertian phase function you get a

649
00:26:34,390 --> 00:26:32,400
substantially different answer for the

650
00:26:36,630 --> 00:26:34,400
geometric albedo

651
00:26:38,390 --> 00:26:36,640
fitted to the polar observations than

652
00:26:40,470 --> 00:26:38,400
you get fitted to the equatorial

653
00:26:41,990 --> 00:26:40,480
observations the equatorial observations

654
00:26:43,990 --> 00:26:42,000
agree with each other

655
00:26:45,669 --> 00:26:44,000
the north and south pole pretty much

656
00:26:46,549 --> 00:26:45,679
agree with each other

657
00:26:47,590 --> 00:26:46,559
but

658
00:26:49,510 --> 00:26:47,600
even though

659
00:26:51,190 --> 00:26:49,520
in principle you know they all belong to

660
00:26:53,590 --> 00:26:51,200
the same planet but you wouldn't

661
00:26:56,789 --> 00:26:53,600
necessarily recognize that if this were

662
00:26:58,870 --> 00:26:56,799
the only kind of data you have

663
00:27:01,110 --> 00:26:58,880

so next steps

664
00:27:03,110 --> 00:27:01,120
well it's been 11 years since we

665
00:27:05,190 --> 00:27:03,120
published that equatorial observation

666
00:27:06,870 --> 00:27:05,200
paper it is time to get out the

667
00:27:10,390 --> 00:27:06,880
companion paper

668
00:27:12,230 --> 00:27:10,400
for the north polar and south polar data

669
00:27:15,269 --> 00:27:12,240
we've also have not yet gotten around to

670
00:27:17,269 --> 00:27:15,279
looking at the rotational modulation of

671
00:27:19,750 --> 00:27:17,279
near-infrared spectral features we have

672
00:27:21,909 --> 00:27:19,760
light curves from the rotation of the

673
00:27:24,149 --> 00:27:21,919
equatorial observations that was in that

674
00:27:25,669 --> 00:27:24,159
astrobiology cover i showed you we

675
00:27:27,750 --> 00:27:25,679
haven't done that to look at the near

676
00:27:30,149 --> 00:27:27,760
infrared components

677
00:27:31,909 --> 00:27:30,159
yet and we haven't looked at how the

678
00:27:34,870 --> 00:27:31,919
molecular absorption bands in the

679
00:27:39,190 --> 00:27:34,880
atmosphere do or do not reflect what's

680
00:27:40,789 --> 00:27:39,200
going on with surface phenomena beneath

681
00:27:42,789 --> 00:27:40,799
we haven't looked at the phase angle

682
00:27:45,669 --> 00:27:42,799
variation of the near-infrared spectral

683
00:27:47,669 --> 00:27:45,679
features so that's got to come up

684
00:27:49,669 --> 00:27:47,679
and we haven't really tried yet i mean

685
00:27:52,230 --> 00:27:49,679
there's a lot to do there's a lot left

686
00:27:54,870 --> 00:27:52,240
to do so we're underway on that um we

687
00:27:57,190 --> 00:27:54,880
had roderick decox paper this morning

688
00:27:59,430 --> 00:27:57,200

and uh he is working on a paper on

689
00:28:02,389 --> 00:27:59,440
modeling our phase behavior for a

690
00:28:03,510 --> 00:28:02,399
spherical model and i'm done did i leave

691
00:28:04,310 --> 00:28:03,520
any time

692
00:28:05,350 --> 00:28:04,320
no

693
00:28:07,269 --> 00:28:05,360
that's me

694
00:28:09,350 --> 00:28:07,279
see roderick's talk is much better

695
00:28:11,190 --> 00:28:09,360
organized than my own there you go you

696
00:28:13,430 --> 00:28:11,200
just hit you just hit it

697
00:28:14,870 --> 00:28:13,440
okay um

698
00:28:16,470 --> 00:28:14,880
all right then uh so are there any

699
00:28:18,470 --> 00:28:16,480
questions for tim

700
00:28:20,549 --> 00:28:18,480
i'd like to come to the

701
00:28:21,669 --> 00:28:20,559
come to the microphones here we go you

702
00:28:24,789 --> 00:28:21,679
have a question

703
00:28:26,950 --> 00:28:24,799
hi i'm angie from purdue university um i

704
00:28:27,990 --> 00:28:26,960
was curious about the equatorial view on

705
00:28:29,430 --> 00:28:28,000
the

706
00:28:31,750 --> 00:28:29,440
big figure you had could you talk a

707
00:28:34,549 --> 00:28:31,760
little bit about the the red limb on the

708
00:28:37,350 --> 00:28:34,559
edge of the atmosphere

709
00:28:39,029 --> 00:28:37,360
well some of that is probably just the

710
00:28:40,149 --> 00:28:39,039
fact that these are data of limited

711
00:28:41,669 --> 00:28:40,159
quality

712
00:28:44,870 --> 00:28:41,679
the the

713
00:28:47,029 --> 00:28:44,880

camera was intrinsically out of focus

714
00:28:49,190 --> 00:28:47,039
the guys from ball aerospace did say

715
00:28:51,029 --> 00:28:49,200
lesson learned never fly a camera that

716
00:28:53,830 --> 00:28:51,039
you can't focus

717
00:28:56,630 --> 00:28:53,840
um and so we do have some some defects

718
00:28:58,710 --> 00:28:56,640
like that for the most part we use the

719
00:29:00,470 --> 00:28:58,720
the direct images of the earth to

720
00:29:01,590 --> 00:29:00,480
convince ourselves that we're not making

721
00:29:03,430 --> 00:29:01,600
things up

722
00:29:04,470 --> 00:29:03,440
but that we don't actually use them for

723
00:29:08,950 --> 00:29:04,480
science

724
00:29:08,960 --> 00:29:15,430
okay let's thank tim again

725
00:29:18,950 --> 00:29:16,389
okay

726
00:29:21,430 --> 00:29:18,960
so our next presentation will be by rudy

727
00:29:22,630 --> 00:29:21,440
garcia

728
00:29:23,750 --> 00:29:22,640
and he will be talking about

729
00:29:25,830 --> 00:29:23,760
demonstrating a diversity of

730
00:29:27,590 --> 00:29:25,840
evolutionary scenarios for venus with

731
00:29:37,029 --> 00:29:27,600
generalizations to stagnant lid

732
00:29:43,990 --> 00:29:41,029
just uh setting my timer real quick

733
00:29:45,350 --> 00:29:44,000
cool hi everybody um yes i will be

734
00:29:47,190 --> 00:29:45,360
demonstrating a diversity of

735
00:29:48,230 --> 00:29:47,200
evolutionary scenarios for venus i'm

736
00:29:50,310 --> 00:29:48,240
going to talk about how we can

737
00:29:52,789 --> 00:29:50,320
generalize those evolutionary scenarios

738
00:29:54,950 --> 00:29:52,799

uh to stagnant lit exoplanets

739
00:29:56,470 --> 00:29:54,960
so firstly when we talk about exoplanets

740
00:29:58,149 --> 00:29:56,480
we want to talk about you know whether

741
00:29:59,510 --> 00:29:58,159
the ones that we observe are habitable

742
00:30:01,909 --> 00:29:59,520
or not because that's where we can

743
00:30:03,269 --> 00:30:01,919
direct a lot of our observation time now

744
00:30:05,350 --> 00:30:03,279
to quantify the habitability of

745
00:30:07,909 --> 00:30:05,360
exoplanets over time because

746
00:30:08,710 --> 00:30:07,919
habitability is a very dynamic concept

747
00:30:12,149 --> 00:30:08,720
you know

748
00:30:13,990 --> 00:30:12,159
whether a planet is in the uh habitable

749
00:30:16,070 --> 00:30:14,000
zone changes based on how its star

750
00:30:18,230 --> 00:30:16,080
evolves so of course to take into

751
00:30:20,070 --> 00:30:18,240
account this dynamic concept we have to

752
00:30:22,789 --> 00:30:20,080
think about different geochemical time

753
00:30:26,549 --> 00:30:22,799
scales specifically what i think a lot

754
00:30:28,310 --> 00:30:26,559
about is the outgassing of water from

755
00:30:30,549 --> 00:30:28,320
the interior of a planet into its

756
00:30:31,909 --> 00:30:30,559
atmosphere through volcanism

757
00:30:34,389 --> 00:30:31,919
and then i think about the atmospheric

758
00:30:37,110 --> 00:30:34,399
escape of that water from the atmosphere

759
00:30:39,029 --> 00:30:37,120
into space and so the balancing of the

760
00:30:41,269 --> 00:30:39,039
time scales of those uh

761
00:30:44,070 --> 00:30:41,279
of those processes typically will tell

762
00:30:45,510 --> 00:30:44,080
us how planets can evolve to either a

763
00:30:47,510 --> 00:30:45,520

state kind of like earth where liquid

764
00:30:49,350 --> 00:30:47,520
water is stable or a state like venus

765
00:30:51,590 --> 00:30:49,360
where liquid water is unstable if you're

766
00:30:53,190 --> 00:30:51,600
interested in these kinds of time scales

767
00:30:54,310 --> 00:30:53,200
like how the stellar evolution affects

768
00:30:57,750 --> 00:30:54,320
all this you should check out evan

769
00:30:59,669 --> 00:30:57,760
davis's talk thursday at 1 25 p.m in 301

770
00:31:01,990 --> 00:30:59,679
305 and if you're interested in the

771
00:31:04,310 --> 00:31:02,000
details of atmospheric escape you can

772
00:31:08,389 --> 00:31:04,320
check out megan gillucci's talk

773
00:31:10,070 --> 00:31:08,399
thursday 3 49 p.m again in 301-305

774
00:31:12,149 --> 00:31:10,080
so in order to take into account these

775
00:31:14,789 --> 00:31:12,159
geochemical processes

776
00:31:16,630 --> 00:31:14,799
we want to model exoplanets now the

777
00:31:18,630 --> 00:31:16,640
issue with that is that exoplanets have

778
00:31:20,310 --> 00:31:18,640
relatively unconstrained interior

779
00:31:21,830 --> 00:31:20,320
properties that can lead to a wide

780
00:31:23,430 --> 00:31:21,840
variety of atmospheres and forward

781
00:31:25,750 --> 00:31:23,440
models there's just not a lot we know

782
00:31:27,830 --> 00:31:25,760
about the interiors of these planets and

783
00:31:29,830 --> 00:31:27,840
so this is where the solar

784
00:31:32,230 --> 00:31:29,840
system comes in instead of looking at

785
00:31:34,070 --> 00:31:32,240
exoplanets we can use venus as a test

786
00:31:36,149 --> 00:31:34,080
bed for models of stagnant lid planet

787
00:31:38,149 --> 00:31:36,159
evolution because it is slightly more

788
00:31:40,230 --> 00:31:38,159

observationally constrained so there's

789
00:31:41,990 --> 00:31:40,240
not a lot we know about venus but we

790
00:31:43,669 --> 00:31:42,000
know more about venus than we do about

791
00:31:44,789 --> 00:31:43,679
basically every other exoplanet out

792
00:31:47,590 --> 00:31:44,799
there

793
00:31:48,710 --> 00:31:47,600
now how do we take uh these models and

794
00:31:51,029 --> 00:31:48,720
how do we

795
00:31:52,950 --> 00:31:51,039
simulate the evolution of the interiors

796
00:31:55,590 --> 00:31:52,960
and atmospheres of these planets well i

797
00:31:57,509 --> 00:31:55,600
do it using v planet which is a code uh

798
00:31:59,830 --> 00:31:57,519
spearheaded by my advisor rory barnes at

799
00:32:01,350 --> 00:31:59,840
the university of washington

800
00:32:02,470 --> 00:32:01,360
the way that it works is it basically

801
00:32:05,430 --> 00:32:02,480
couples all of these different

802
00:32:07,669 --> 00:32:05,440
differential equations that uh model the

803
00:32:09,909 --> 00:32:07,679
different geological processes and then

804
00:32:11,909 --> 00:32:09,919
evolve the planet over time so for

805
00:32:13,990 --> 00:32:11,919
example if we look at the atmosphere

806
00:32:15,190 --> 00:32:14,000
layer of the planet we can see that

807
00:32:18,070 --> 00:32:15,200
magma

808
00:32:20,710 --> 00:32:18,080
and extrusive volcanism eruptions they

809
00:32:23,190 --> 00:32:20,720
outgas volatiles especially water into

810
00:32:25,269 --> 00:32:23,200
the atmosphere and then potentially

811
00:32:27,669 --> 00:32:25,279
depending on the xuv radiation

812
00:32:29,430 --> 00:32:27,679
environment in that planet's uh

813
00:32:33,110 --> 00:32:29,440

stratosphere that water could be

814
00:32:35,590 --> 00:32:33,120
fertilized and escape out into space

815
00:32:38,310 --> 00:32:35,600
now the rate of eruptions over time

816
00:32:39,590 --> 00:32:38,320
tells us how much water reaches in

817
00:32:41,350 --> 00:32:39,600
reaches the atmosphere over time

818
00:32:44,310 --> 00:32:41,360
potentially to replenish any that's

819
00:32:46,789 --> 00:32:44,320
escaped and in order to track

820
00:32:48,149 --> 00:32:46,799
my bad um if you're interested in how we

821
00:32:50,549 --> 00:32:48,159
can view these atmospheres you should

822
00:32:53,669 --> 00:32:50,559
check out miles curry's talk at tuesday

823
00:32:55,190 --> 00:32:53,679
1 15 pm again in 301 305 and if you're

824
00:32:56,230 --> 00:32:55,200
interested in how we know what we're

825
00:32:58,070 --> 00:32:56,240
looking at when we look at these

826
00:33:00,149 --> 00:32:58,080
exoplanet atmospheres you should look at

827
00:33:02,710 --> 00:33:00,159
samantha gilbert's talk friday at 1 pm

828
00:33:05,990 --> 00:33:02,720
again in 301 305 i guess i'm the only

829
00:33:10,149 --> 00:33:07,750
so in order to track these eruptions

830
00:33:12,950 --> 00:33:10,159
over time we need to model how the

831
00:33:15,110 --> 00:33:12,960
planet's mantle changes you see the the

832
00:33:17,750 --> 00:33:15,120
mantle is heated primarily by the decay

833
00:33:18,870 --> 00:33:17,760
of radioisotopes and by heat flow from

834
00:33:20,470 --> 00:33:18,880
the core

835
00:33:23,029 --> 00:33:20,480
and then the mantle has two distinct

836
00:33:25,590 --> 00:33:23,039
ways to cool one way it cools is through

837
00:33:28,070 --> 00:33:25,600
those eruptions if you erupt all the hot

838
00:33:30,149 --> 00:33:28,080

melted rock you cool off the mantle and

839
00:33:32,230 --> 00:33:30,159
what's key to that is that by erupting

840
00:33:34,789 --> 00:33:32,240
that hot melted rock you're taking

841
00:33:36,470 --> 00:33:34,799
volatiles like water or carbon dioxide

842
00:33:38,230 --> 00:33:36,480
and putting them from the interior into

843
00:33:39,750 --> 00:33:38,240
the atmosphere

844
00:33:42,230 --> 00:33:39,760
the other way that mantle's cool is

845
00:33:45,269 --> 00:33:42,240
through convection convection basically

846
00:33:47,669 --> 00:33:45,279
you know rotates uh the mantle and it

847
00:33:49,590 --> 00:33:47,679
pushes sort of hot rock upwards and

848
00:33:52,230 --> 00:33:49,600
pulls cool rock downwards

849
00:33:54,710 --> 00:33:52,240
now convection is limited by this

850
00:33:56,149 --> 00:33:54,720
thermal boundary layer in the mantle

851
00:33:58,870 --> 00:33:56,159
at that thermal boundary layer

852
00:34:02,149 --> 00:33:58,880
convection kind of stops being efficient

853
00:34:03,669 --> 00:34:02,159
and heat mostly gets out via conduction

854
00:34:05,909 --> 00:34:03,679
and then getting out through conduction

855
00:34:08,389 --> 00:34:05,919
continues on in the crust and so no

856
00:34:09,990 --> 00:34:08,399
matter how convective your mantle is

857
00:34:12,069 --> 00:34:10,000
your heat transfer is still going to be

858
00:34:14,230 --> 00:34:12,079
limited by that conductive thermal

859
00:34:17,349 --> 00:34:14,240
boundary layer which is determined by

860
00:34:18,790 --> 00:34:17,359
sort of how viscous your mantle is

861
00:34:21,030 --> 00:34:18,800
so that thermal boundary layer

862
00:34:23,030 --> 00:34:21,040
represents the beginning of the crust

863
00:34:24,069 --> 00:34:23,040

and potentially the stagnant lid which

864
00:34:25,510 --> 00:34:24,079
is true because we're going to be

865
00:34:27,510 --> 00:34:25,520
talking about venus

866
00:34:29,349 --> 00:34:27,520
in fact if we follow those volatiles the

867
00:34:30,629 --> 00:34:29,359
water the carbon dioxide and the

868
00:34:33,589 --> 00:34:30,639
incompatible elements like the

869
00:34:36,869 --> 00:34:33,599
radioisotopes in the magma that magma

870
00:34:38,629 --> 00:34:36,879
will melt it'll rise and while some of

871
00:34:41,030 --> 00:34:38,639
it does get erupted to the surface and

872
00:34:42,710 --> 00:34:41,040
outgasses many of those volatiles will

873
00:34:44,550 --> 00:34:42,720
actually be trapped in the crust and

874
00:34:47,109 --> 00:34:44,560
this is called intrusive volcanism

875
00:34:49,510 --> 00:34:47,119
because it's intruding into the crust

876
00:34:50,550 --> 00:34:49,520
now on planets like earth with tectonic

877
00:34:52,389 --> 00:34:50,560
plates

878
00:34:54,710 --> 00:34:52,399
any volatiles that are stuck in the

879
00:34:57,430 --> 00:34:54,720
crust are relatively easily recycled

880
00:34:59,430 --> 00:34:57,440
back into the mantle through subduction

881
00:35:01,750 --> 00:34:59,440
related processes

882
00:35:04,310 --> 00:35:01,760
however on a planet like venus with a

883
00:35:05,990 --> 00:35:04,320
stagnant lid um it's kind of more up in

884
00:35:08,630 --> 00:35:06,000
the air whether those volatiles will get

885
00:35:10,870 --> 00:35:08,640
recycled back in however recent work uh

886
00:35:11,829 --> 00:35:10,880
such as brad foley's work uh has shown

887
00:35:14,470 --> 00:35:11,839
that

888
00:35:16,150 --> 00:35:14,480

even though stagnant-lid exoplanets uh

889
00:35:18,790 --> 00:35:16,160
and stagnant-lid planets don't have

890
00:35:21,109 --> 00:35:18,800
tectonic plates they can in fact uh

891
00:35:23,430 --> 00:35:21,119
recycle some of those volatiles back

892
00:35:25,430 --> 00:35:23,440
into the mantle uh mostly through phase

893
00:35:27,510 --> 00:35:25,440
changes and density changes that occur

894
00:35:29,270 --> 00:35:27,520
on the lower crust causes that lower

895
00:35:32,150 --> 00:35:29,280
crust region to sink back into the

896
00:35:34,630 --> 00:35:32,160
mantle bringing back those volatiles and

897
00:35:36,390 --> 00:35:34,640
kind of completing the cycle

898
00:35:39,109 --> 00:35:36,400
now like i said the mantle is also

899
00:35:41,349 --> 00:35:39,119
heated by the by the core and the core

900
00:35:43,829 --> 00:35:41,359
itself is mostly heated by either

901
00:35:45,990 --> 00:35:43,839
secular sort of leftover heat from

902
00:35:48,310 --> 00:35:46,000
formation and by the decay of

903
00:35:50,470 --> 00:35:48,320
radioisotopes now the core mostly gets

904
00:35:52,790 --> 00:35:50,480
that heat out through convection and if

905
00:35:54,710 --> 00:35:52,800
the core convects vigorously enough then

906
00:35:55,990 --> 00:35:54,720
we're going to have a magnetic field on

907
00:35:57,829 --> 00:35:56,000
this planet which is something that we

908
00:35:59,190 --> 00:35:57,839
can potentially observe

909
00:36:01,910 --> 00:35:59,200
the other interesting thing about the

910
00:36:03,510 --> 00:36:01,920
core convection is it really relies on

911
00:36:05,750 --> 00:36:03,520
whatever the temperature of the lower

912
00:36:07,430 --> 00:36:05,760
mantle is that kind of limits whether

913
00:36:09,349 --> 00:36:07,440

the core is going to convect very

914
00:36:11,670 --> 00:36:09,359
vigorously or if it's not going to

915
00:36:13,750 --> 00:36:11,680
convect much at all

916
00:36:15,670 --> 00:36:13,760
and so overall when we put all these

917
00:36:17,829 --> 00:36:15,680
layers together we get this kind of

918
00:36:19,829 --> 00:36:17,839
whole planet coupling approach and the

919
00:36:22,230 --> 00:36:19,839
reason we do this is because as you can

920
00:36:24,630 --> 00:36:22,240
see each of these layers kind of acts as

921
00:36:27,270 --> 00:36:24,640
a boundary condition for all the other

922
00:36:29,349 --> 00:36:27,280
processes in the in the planet

923
00:36:30,870 --> 00:36:29,359
convection in the mantle is limited by

924
00:36:32,950 --> 00:36:30,880
the thermal boundary layer which is

925
00:36:34,710 --> 00:36:32,960
itself kind of due to the viscosity of

926
00:36:36,710 --> 00:36:34,720
that mantle and the viscosity of the

927
00:36:38,550 --> 00:36:36,720
mantle changes based on the temperature

928
00:36:40,390 --> 00:36:38,560
of the mantle and the amount of water in

929
00:36:42,310 --> 00:36:40,400
the mantle but of course the mantle is

930
00:36:44,550 --> 00:36:42,320
getting heated by the core uh and

931
00:36:45,990 --> 00:36:44,560
whether the core convects uh vigorously

932
00:36:47,910 --> 00:36:46,000
enough for a magnetic field well that's

933
00:36:49,589 --> 00:36:47,920
limited by the mantle temperature so you

934
00:36:52,230 --> 00:36:49,599
get these really interesting and kind of

935
00:36:54,150 --> 00:36:52,240
complicated feedbacks um

936
00:36:57,030 --> 00:36:54,160
that i'm going to go into in sort of

937
00:36:58,390 --> 00:36:57,040
detail enough detail for for this talk

938
00:37:00,310 --> 00:36:58,400

now looking at this model you can see

939
00:37:01,910 --> 00:37:00,320
that there's lots of knobs to turn here

940
00:37:02,790 --> 00:37:01,920
this is a really high dimensional

941
00:37:04,470 --> 00:37:02,800
problem

942
00:37:06,550 --> 00:37:04,480
and it requires a thorough exploration

943
00:37:09,270 --> 00:37:06,560
of parameter space to find our distinct

944
00:37:12,150 --> 00:37:09,280
evolutionary tracks so what we did is we

945
00:37:14,630 --> 00:37:12,160
ran about 24 000 simulations sampling

946
00:37:16,470 --> 00:37:14,640
about 15 different parameters which if

947
00:37:18,550 --> 00:37:16,480
you're interested in the real details

948
00:37:21,030 --> 00:37:18,560
you can talk to me later but we took

949
00:37:23,589 --> 00:37:21,040
those simulations and then we took the

950
00:37:25,910 --> 00:37:23,599
subset of those simulations that matched

951
00:37:28,390 --> 00:37:25,920
modern day venus so our constraints for

952
00:37:30,310 --> 00:37:28,400
venus are threefold the water in its

953
00:37:32,390 --> 00:37:30,320
atmosphere the carbon dioxide in its

954
00:37:34,870 --> 00:37:32,400
atmosphere and the fact that we don't

955
00:37:36,550 --> 00:37:34,880
see a magnetic field on venus

956
00:37:38,550 --> 00:37:36,560
there is actually a little bit of water

957
00:37:39,990 --> 00:37:38,560
in venus's atmosphere it's at about 30

958
00:37:41,510 --> 00:37:40,000
parts per million

959
00:37:43,270 --> 00:37:41,520
so there's a little bit that we can

960
00:37:44,710 --> 00:37:43,280
constrain

961
00:37:46,710 --> 00:37:44,720
so on this next slide i'm showing the

962
00:37:48,390 --> 00:37:46,720
diversity of evolutionary scenarios that

963
00:37:50,390 --> 00:37:48,400

lead to modern venus

964
00:37:52,390 --> 00:37:50,400
each of these lines represents a single

965
00:37:56,150 --> 00:37:52,400
choice of parameters for a single

966
00:37:57,990 --> 00:37:56,160
simulation over time so this top uh

967
00:37:59,910 --> 00:37:58,000
this top figure represents how much

968
00:38:01,670 --> 00:37:59,920
water is in the atmosphere of venus over

969
00:38:03,670 --> 00:38:01,680
time um

970
00:38:05,510 --> 00:38:03,680
in the middle we can see how much carbon

971
00:38:06,790 --> 00:38:05,520
dioxide is in the atmosphere over time

972
00:38:08,550 --> 00:38:06,800
and on the bottom we can see what the

973
00:38:09,990 --> 00:38:08,560
magnetic moment of the planet is over

974
00:38:12,310 --> 00:38:10,000
time

975
00:38:13,829 --> 00:38:12,320
the different colors represent different

976
00:38:16,390 --> 00:38:13,839
groupings different potential

977
00:38:18,790 --> 00:38:16,400
evolutionary scenarios you see while

978
00:38:21,829 --> 00:38:18,800
different scenarios converge on our

979
00:38:24,950 --> 00:38:21,839
define constraints they can divert they

980
00:38:27,349 --> 00:38:24,960
diverge for other values so on the top

981
00:38:29,510 --> 00:38:27,359
layer here we can see the top row has

982
00:38:31,109 --> 00:38:29,520
again on the left the amount of water in

983
00:38:33,030 --> 00:38:31,119
the atmosphere and on the right the

984
00:38:34,550 --> 00:38:33,040
magnetic moment of the planet

985
00:38:36,790 --> 00:38:34,560
but on the bottom we can look at some of

986
00:38:38,790 --> 00:38:36,800
these derived parameters

987
00:38:41,030 --> 00:38:38,800
where we can see divergence in these

988
00:38:42,630 --> 00:38:41,040

evolutionary scenarios the bottom left

989
00:38:44,230 --> 00:38:42,640
we've got the surface heat flow of the

990
00:38:46,230 --> 00:38:44,240
planet and you can see that you know

991
00:38:48,310 --> 00:38:46,240
these blue simulations end up with high

992
00:38:50,230 --> 00:38:48,320
heat flows and these kind of pale white

993
00:38:52,230 --> 00:38:50,240
purple simulations end up with very low

994
00:38:54,550 --> 00:38:52,240
surface heat flows and then of course

995
00:38:56,710 --> 00:38:54,560
we've got the uh percent of the core

996
00:38:58,630 --> 00:38:56,720
that's frozen uh and that's in the

997
00:39:00,470 --> 00:38:58,640
bottom right and there are all these red

998
00:39:02,069 --> 00:39:00,480
simulations that

999
00:39:03,589 --> 00:39:02,079
end up with venus having a slightly

1000
00:39:05,670 --> 00:39:03,599
liquid core

1001
00:39:07,030 --> 00:39:05,680
and so what we've defined here what i've

1002
00:39:08,230 --> 00:39:07,040
done a lot of work doing is sort of

1003
00:39:10,630 --> 00:39:08,240
categorizing these potential

1004
00:39:12,870 --> 00:39:10,640
evolutionary scenarios we've got in the

1005
00:39:15,589 --> 00:39:12,880
red these

1006
00:39:17,430 --> 00:39:15,599
scenarios that end in a liquid core and

1007
00:39:20,630 --> 00:39:17,440
in the sort of white yellow we've got

1008
00:39:22,550 --> 00:39:20,640
these low melt fraction scenarios

1009
00:39:23,829 --> 00:39:22,560
where venus ends up with a very low melt

1010
00:39:25,910 --> 00:39:23,839
fraction

1011
00:39:27,430 --> 00:39:25,920
if you look closely at the top left plot

1012
00:39:30,310 --> 00:39:27,440
you'll see that all of those sort of

1013
00:39:31,430 --> 00:39:30,320

whitish yellow purple simulations um

1014
00:39:33,510 --> 00:39:31,440
those are all

1015
00:39:36,069 --> 00:39:33,520
really rapidly decreasing and so this is

1016
00:39:37,990 --> 00:39:36,079
actually a very transient scenario um in

1017
00:39:40,230 --> 00:39:38,000
these simulations venus has such a low

1018
00:39:42,470 --> 00:39:40,240
melt fraction that melting is actually

1019
00:39:45,030 --> 00:39:42,480
about to stop and so if i continued

1020
00:39:47,910 --> 00:39:45,040
these simulations past 4.5 billion years

1021
00:39:50,310 --> 00:39:47,920
even to something like 4.7 billion years

1022
00:39:51,910 --> 00:39:50,320
venus would lose its water

1023
00:39:54,870 --> 00:39:51,920
in its atmosphere because melting would

1024
00:39:56,390 --> 00:39:54,880
stop and outgassing would stop

1025
00:39:58,710 --> 00:39:56,400
now what's really cool and something

1026
00:40:00,230 --> 00:39:58,720
i've been working towards is trying to

1027
00:40:02,069 --> 00:40:00,240
find the differences in these

1028
00:40:03,990 --> 00:40:02,079
evolutionary scenarios that could be

1029
00:40:05,670 --> 00:40:04,000
distinguished observationally by future

1030
00:40:07,910 --> 00:40:05,680
venus missions so this is a pretty

1031
00:40:10,390 --> 00:40:07,920
complicated staircase plot each point

1032
00:40:12,470 --> 00:40:10,400
represents a different simulation

1033
00:40:14,710 --> 00:40:12,480
in this five-dimensional parameter space

1034
00:40:15,910 --> 00:40:14,720
defined by potential observables on

1035
00:40:17,829 --> 00:40:15,920
venus

1036
00:40:18,950 --> 00:40:17,839
all i really wanted to talk about this

1037
00:40:20,630 --> 00:40:18,960
plot though because i don't have much

1038
00:40:22,309 --> 00:40:20,640

time is that you can see that the

1039
00:40:25,109 --> 00:40:22,319
color-coded groupings are

1040
00:40:27,589 --> 00:40:25,119
distinguishable for certain observables

1041
00:40:29,030 --> 00:40:27,599
especially the surface heat flow of the

1042
00:40:30,630 --> 00:40:29,040
planet i don't know much about the

1043
00:40:32,309 --> 00:40:30,640
future venus missions but i came to

1044
00:40:33,829 --> 00:40:32,319
abscicon to find out more because i

1045
00:40:36,870 --> 00:40:33,839
think there might be some cool stuff we

1046
00:40:38,950 --> 00:40:36,880
can learn about venus's past

1047
00:40:40,470 --> 00:40:38,960
lastly i want to say that the evolutions

1048
00:40:42,470 --> 00:40:40,480
that result in a venus with low melt

1049
00:40:44,950 --> 00:40:42,480
fractions lose a larger amount of water

1050
00:40:47,030 --> 00:40:44,960
to space so on this top panel we can see

1051
00:40:49,109 --> 00:40:47,040
how much water is lost for each

1052
00:40:50,710 --> 00:40:49,119
individual point simulation

1053
00:40:52,790 --> 00:40:50,720
from the mantle and the bottom two

1054
00:40:54,950 --> 00:40:52,800
panels we can see where that water goes

1055
00:40:56,790 --> 00:40:54,960
you can see that these uh simulations

1056
00:40:58,870 --> 00:40:56,800
that end in a low melt fraction they

1057
00:41:00,870 --> 00:40:58,880
actually lose much more water to space

1058
00:41:02,950 --> 00:41:00,880
than basically all the other simulations

1059
00:41:04,470 --> 00:41:02,960
um that's interesting we might be able

1060
00:41:06,710 --> 00:41:04,480
to predict some sort of observational

1061
00:41:09,030 --> 00:41:06,720
discriminant from for example the ddh

1062
00:41:10,550 --> 00:41:09,040
ratio in venus's atmosphere i'm going to

1063
00:41:12,470 --> 00:41:10,560

skip this slide it's got a lot of

1064
00:41:13,990 --> 00:41:12,480
details but i don't have much time i

1065
00:41:15,589 --> 00:41:14,000
want to leave time for questions so my

1066
00:41:17,349 --> 00:41:15,599
conclusions are that whole planet

1067
00:41:18,950 --> 00:41:17,359
coupling is needed to both match solar

1068
00:41:21,030 --> 00:41:18,960
system planets and take into account

1069
00:41:22,550 --> 00:41:21,040
interactions on exoplanets venus could

1070
00:41:25,030 --> 00:41:22,560
be in the process of water loss from the

1071
00:41:26,630 --> 00:41:25,040
mantle due to dearth of magmatism or it

1072
00:41:27,990 --> 00:41:26,640
could be in a relatively steady state

1073
00:41:30,470 --> 00:41:28,000
with the meager amount of water being

1074
00:41:32,069 --> 00:41:30,480
replenished by outcasting and lastly

1075
00:41:33,990 --> 00:41:32,079
venus histories that match modern day

1076
00:41:35,910 --> 00:41:34,000
observations cover a wide range of

1077
00:41:37,670 --> 00:41:35,920
parameter space that demonstrate both

1078
00:41:39,349 --> 00:41:37,680
the evolutions that exoplanets could

1079
00:41:40,870 --> 00:41:39,359
have and the need for analysis

1080
00:41:49,750 --> 00:41:40,880
techniques that take into account the

1081
00:41:53,430 --> 00:41:50,710
thanks

1082
00:41:56,309 --> 00:41:53,440
okay questions

1083
00:41:58,230 --> 00:41:56,319
auntie hello anthony from the national

1084
00:42:10,230 --> 00:41:58,240
university of mexico

1085
00:42:17,910 --> 00:42:13,829
oh this one sorry is that so what i see

1086
00:42:19,589 --> 00:42:17,920
i see there is that uh the core

1087
00:42:21,270 --> 00:42:19,599
is frozen

1088
00:42:23,030 --> 00:42:21,280

for those red lines some of those

1089
00:42:26,390 --> 00:42:23,040
straight lines and then

1090
00:42:27,430 --> 00:42:26,400
the the frozen part shrinks right

1091
00:42:29,750 --> 00:42:27,440
yeah

1092
00:42:32,150 --> 00:42:29,760
where does the heat come

1093
00:42:33,750 --> 00:42:32,160
what is going on there yeah so i think

1094
00:42:35,750 --> 00:42:33,760
what's probably going on there for the

1095
00:42:38,550 --> 00:42:35,760
simulations where the

1096
00:42:40,069 --> 00:42:38,560
uh core actually starts frozen and sort

1097
00:42:42,470 --> 00:42:40,079
of starts melting

1098
00:42:45,190 --> 00:42:42,480
is i think the cores is actually heating

1099
00:42:47,910 --> 00:42:45,200
up potentially due to

1100
00:42:51,589 --> 00:42:47,920
changes in the lower mantle so if you

1101
00:42:54,230 --> 00:42:51,599
imagine right if the lower mantle

1102
00:42:56,470 --> 00:42:54,240
heats up a lot due to whatever is going

1103
00:42:59,589 --> 00:42:56,480
on up there then the temperature

1104
00:43:01,510 --> 00:42:59,599
difference between the um

1105
00:43:04,230 --> 00:43:01,520
the core and the lower mantle is going

1106
00:43:06,150 --> 00:43:04,240
to go really low and so the the core

1107
00:43:08,230 --> 00:43:06,160
isn't going to be able to get heat out

1108
00:43:10,470 --> 00:43:08,240
very quickly and that's going to result

1109
00:43:12,550 --> 00:43:10,480
in the core net heating over time and

1110
00:43:13,990 --> 00:43:12,560
that melts the core a little bit so

1111
00:43:16,150 --> 00:43:14,000
really it's it's kind of a whole planet

1112
00:43:18,069 --> 00:43:16,160
coupling thing the the the lower mantle

1113
00:43:19,910 --> 00:43:18,079

sets the boundary condition for the core

1114
00:43:22,150 --> 00:43:19,920
and if whatever weird stuff is going on

1115
00:43:25,030 --> 00:43:22,160
in the mantle kind of uh trickles down

1116
00:43:28,630 --> 00:43:25,040
to really influence the core

1117
00:43:31,270 --> 00:43:28,640
thanks all right tessa and then tim

1118
00:43:32,470 --> 00:43:31,280
hi tessa fisher hey um asu

1119
00:43:35,190 --> 00:43:32,480
um

1120
00:43:37,270 --> 00:43:35,200
did your research shed any light on

1121
00:43:39,829 --> 00:43:37,280
sort of the opposite question of why do

1122
00:43:41,349 --> 00:43:39,839
certain planets

1123
00:43:44,710 --> 00:43:41,359
a stagnant lid

1124
00:43:46,230 --> 00:43:44,720
um sort of step uh end state i know per

1125
00:43:48,309 --> 00:43:46,240
earth i've seen that attributed to

1126
00:43:50,950 --> 00:43:48,319
everything from having a biosphere to

1127
00:43:52,069 --> 00:43:50,960
the giant moon forming impact

1128
00:43:54,630 --> 00:43:52,079
yeah i think that's a really good

1129
00:43:56,390 --> 00:43:54,640
question as to why planets don't enter a

1130
00:43:58,470 --> 00:43:56,400
stagnant lid especially if we take

1131
00:43:59,829 --> 00:43:58,480
stagnantly that's the kind of default um

1132
00:44:01,430 --> 00:43:59,839
i haven't really looked into that we

1133
00:44:03,510 --> 00:44:01,440
kind of in this work i just kind of

1134
00:44:05,349 --> 00:44:03,520
assumed venus has a stagnant lid the

1135
00:44:07,190 --> 00:44:05,359
whole time but it's something i'd love

1136
00:44:08,390 --> 00:44:07,200
to look more into and incorporate into

1137
00:44:09,270 --> 00:44:08,400
my models

1138
00:44:10,069 --> 00:44:09,280

thank you

1139
00:44:11,270 --> 00:44:10,079
okay

1140
00:44:12,950 --> 00:44:11,280
quick question and quick answer all

1141
00:44:14,870 --> 00:44:12,960
right tim livengood university of

1142
00:44:17,750 --> 00:44:14,880
maryland and uh goddard space flight

1143
00:44:19,589 --> 00:44:17,760
center uh i'm i am hungry for something

1144
00:44:21,109 --> 00:44:19,599
that's at a next level of detail that

1145
00:44:23,750 --> 00:44:21,119
you didn't get into which is in the

1146
00:44:26,309 --> 00:44:23,760
atmospheric loss process uh if you can

1147
00:44:28,150 --> 00:44:26,319
make predictions for the enrichment of

1148
00:44:29,349 --> 00:44:28,160
heavy isotopes

1149
00:44:31,589 --> 00:44:29,359
because that's something that we can

1150
00:44:33,589 --> 00:44:31,599
measure both remotely and then

1151
00:44:34,950 --> 00:44:33,599
when when da vinci gets there and

1152
00:44:36,309 --> 00:44:34,960
plunges through

1153
00:44:39,030 --> 00:44:36,319
and actually get some direct

1154
00:44:40,550 --> 00:44:39,040
measurements on co2 and water and so on

1155
00:44:42,630 --> 00:44:40,560
in the atmosphere

1156
00:44:43,990 --> 00:44:42,640
so could you would it be possible to

1157
00:44:45,750 --> 00:44:44,000
incorporate that

1158
00:44:48,150 --> 00:44:45,760
uh yeah i would love to it's something i

1159
00:44:50,069 --> 00:44:48,160
looked at a while back but ran into some

1160
00:44:52,550 --> 00:44:50,079
issues with but i'd love to talk offline

1161
00:44:54,550 --> 00:44:52,560
later about how i can incorporate

1162
00:44:59,349 --> 00:44:54,560
uh more observable concepts into these

1163
00:45:02,470 --> 00:45:01,030

okay unfortunately we're gonna have to

1164
00:45:03,910 --> 00:45:02,480
move on so if you could if you could ask

1165
00:45:06,069 --> 00:45:03,920
rudy he's just going to be sitting right

1166
00:45:07,910 --> 00:45:06,079
here after the break that would be great

1167
00:45:09,510 --> 00:45:07,920
all right so we are now moving to a

1168
00:45:11,109 --> 00:45:09,520
remote presenter and i'm going to hand

1169
00:45:17,430 --> 00:45:11,119
over to stephanie

1170
00:45:23,109 --> 00:45:19,990
all right our next speaker is johnny

1171
00:45:25,270 --> 00:45:23,119
seals of rice university and johnny will

1172
00:45:27,430 --> 00:45:25,280
be speaking to us about

1173
00:45:37,670 --> 00:45:27,440
the species richness of exoplanet

1174
00:45:42,230 --> 00:45:40,870
johnny can you bring your slides back up

1175
00:45:43,829 --> 00:45:42,240
there you go can you see them okay and

1176
00:45:45,990 --> 00:45:43,839
can you hear me

1177
00:45:50,630 --> 00:45:46,000
yes

1178
00:45:52,230 --> 00:45:50,640
discussing the species richness of

1179
00:45:54,230 --> 00:45:52,240
terrestrial vertebrates and rocky

1180
00:45:56,630 --> 00:45:54,240
exoplanets i've done this work in

1181
00:45:58,309 --> 00:45:56,640
conjunction with some collaborators

1182
00:46:01,109 --> 00:45:58,319
listed at the bottom of the screen that

1183
00:46:03,589 --> 00:46:01,119
range from geomorphologists to

1184
00:46:04,950 --> 00:46:03,599
structural geologists to biologists one

1185
00:46:07,030 --> 00:46:04,960
of the interesting things that they've

1186
00:46:09,990 --> 00:46:07,040
taught me is that most terrestrial

1187
00:46:12,309 --> 00:46:10,000
vertebrates live in the mountains

1188
00:46:15,430 --> 00:46:12,319

i think that this is depicted well uh

1189
00:46:18,230 --> 00:46:15,440
within this uh figure from robec at all

1190
00:46:20,390 --> 00:46:18,240
2019 where they're showing for mammal

1191
00:46:23,190 --> 00:46:20,400
bird and amphibian species the

1192
00:46:26,150 --> 00:46:23,200
proportion of species range in mountains

1193
00:46:27,510 --> 00:46:26,160
and lowlands so at the lower greens or

1194
00:46:29,109 --> 00:46:27,520
at the lighter greens many of the

1195
00:46:31,829 --> 00:46:29,119
species are living in the lowlands

1196
00:46:34,150 --> 00:46:31,839
whereas at the darker greens and into

1197
00:46:36,230 --> 00:46:34,160
the black the species are more

1198
00:46:38,390 --> 00:46:36,240
inhabiting higher elevations or in the

1199
00:46:41,030 --> 00:46:38,400
mountains so they actually found that

1200
00:46:43,109 --> 00:46:41,040
about 87 of all of these species are

1201
00:46:46,230 --> 00:46:43,119
living within the mountains this also

1202
00:46:48,230 --> 00:46:46,240
reminded me of an interesting

1203
00:46:51,030 --> 00:46:48,240
problem related to geodynamics one

1204
00:46:53,670 --> 00:46:51,040
that's often given within the context of

1205
00:46:55,990 --> 00:46:53,680
some modeling classes and that's can you

1206
00:46:58,390 --> 00:46:56,000
estimate what the maximum height of a

1207
00:46:59,430 --> 00:46:58,400
mountain will be based on a planetary

1208
00:47:01,990 --> 00:46:59,440
size

1209
00:47:03,270 --> 00:47:02,000
so one way to go about doing this is to

1210
00:47:05,670 --> 00:47:03,280
assume that

1211
00:47:07,190 --> 00:47:05,680
the stress imposed by an overlying

1212
00:47:08,950 --> 00:47:07,200
column of rock

1213
00:47:11,030 --> 00:47:08,960

is going to get

1214
00:47:14,150 --> 00:47:11,040
is going to increase as the height of

1215
00:47:17,109 --> 00:47:14,160
the mountain increases once it

1216
00:47:19,270 --> 00:47:17,119
once it surpasses a particular threshold

1217
00:47:20,790 --> 00:47:19,280
the rock below will crack so that's

1218
00:47:23,829 --> 00:47:20,800
going to give us the highest mountain

1219
00:47:25,750 --> 00:47:23,839
that we could have now if we think of a

1220
00:47:28,549 --> 00:47:25,760
planet and then reduce

1221
00:47:31,349 --> 00:47:28,559
uh compare it to a planet that is less

1222
00:47:33,990 --> 00:47:31,359
massive which will have a lower gravity

1223
00:47:35,910 --> 00:47:34,000
then uh due to that reduction in gravity

1224
00:47:38,630 --> 00:47:35,920
the maximum height of the mountain will

1225
00:47:41,190 --> 00:47:38,640
actually increase we can think about

1226
00:47:43,829 --> 00:47:41,200
whether or not this bears out in our own

1227
00:47:45,270 --> 00:47:43,839
solar system and

1228
00:47:48,309 --> 00:47:45,280
essentially it does

1229
00:47:50,630 --> 00:47:48,319
for earth the largest mountain itself is

1230
00:47:52,790 --> 00:47:50,640
approximately 10 kilometers whereas on

1231
00:47:55,670 --> 00:47:52,800
mars a smaller planet the largest

1232
00:47:56,470 --> 00:47:55,680
mountain is around 24 kilometers

1233
00:47:58,950 --> 00:47:56,480
so

1234
00:48:01,670 --> 00:47:58,960
when we take these two pieces of

1235
00:48:03,750 --> 00:48:01,680
information together it

1236
00:48:05,430 --> 00:48:03,760
suggested to our group that we could ask

1237
00:48:07,589 --> 00:48:05,440
how does the species richness of

1238
00:48:09,190 --> 00:48:07,599

terrestrial vertebrates vary with

1239
00:48:10,630 --> 00:48:09,200
planetary mass

1240
00:48:12,950 --> 00:48:10,640
we'll go about trying to create a

1241
00:48:14,630 --> 00:48:12,960
theoretical model to answer that using

1242
00:48:17,030 --> 00:48:14,640
the following equation

1243
00:48:18,790 --> 00:48:17,040
we'll first step through the

1244
00:48:20,710 --> 00:48:18,800
calculating the number of species per

1245
00:48:22,549 --> 00:48:20,720
unit area and how that varies with

1246
00:48:24,630 --> 00:48:22,559
height

1247
00:48:27,190 --> 00:48:24,640
the way that this was done is that maya

1248
00:48:29,589 --> 00:48:27,200
stepped through some some data sources

1249
00:48:32,150 --> 00:48:29,599
and looked at the number of species that

1250
00:48:35,349 --> 00:48:32,160
were out there and took each species

1251
00:48:38,069 --> 00:48:35,359
estimated its average elevation that it

1252
00:48:41,829 --> 00:48:38,079
occupied and then bend all of those

1253
00:48:43,750 --> 00:48:41,839
species into 200 meter elevation bins

1254
00:48:44,790 --> 00:48:43,760
simultaneously she took

1255
00:48:47,750 --> 00:48:44,800
the

1256
00:48:50,950 --> 00:48:47,760
global relief model that is two by two

1257
00:48:54,790 --> 00:48:50,960
cells and took each of the elevations

1258
00:48:57,270 --> 00:48:54,800
and bend those into uh 200 meter bins as

1259
00:49:00,790 --> 00:48:57,280
well so this allowed for an estimation

1260
00:49:02,309 --> 00:49:00,800
of the surface area for a particular bin

1261
00:49:05,829 --> 00:49:02,319
you can take and divide the number

1262
00:49:07,670 --> 00:49:05,839
species by the area of the bin that it

1263
00:49:10,390 --> 00:49:07,680

inhabits

1264
00:49:12,790 --> 00:49:10,400
and she found these results here is

1265
00:49:16,630 --> 00:49:12,800
showing elevation on the horizontal axis

1266
00:49:19,589 --> 00:49:16,640
so zero to five kilometers and then uh

1267
00:49:20,790 --> 00:49:19,599
the data resulting of the species per

1268
00:49:23,829 --> 00:49:20,800
unit per

1269
00:49:26,230 --> 00:49:23,839
uh square kilometer on the vertical axis

1270
00:49:27,510 --> 00:49:26,240
and this is going for amphibians birds

1271
00:49:28,870 --> 00:49:27,520
and mammals

1272
00:49:31,430 --> 00:49:28,880
the same

1273
00:49:32,790 --> 00:49:31,440
signature is seen within the data where

1274
00:49:38,950 --> 00:49:32,800
at

1275
00:49:41,030 --> 00:49:38,960
of species per unit area increases

1276
00:49:42,950 --> 00:49:41,040
this continues until approximately three

1277
00:49:46,710 --> 00:49:42,960
kilometers where there's a rollover and

1278
00:49:49,190 --> 00:49:46,720
the number of species begins to decline

1279
00:49:51,910 --> 00:49:49,200
now to use this within our theoretical

1280
00:49:53,510 --> 00:49:51,920
model we fit uh

1281
00:49:56,069 --> 00:49:53,520
this equation to

1282
00:49:58,390 --> 00:49:56,079
we chose this equation over

1283
00:50:00,870 --> 00:49:58,400
a regular quadratic to capture some of

1284
00:50:04,150 --> 00:50:00,880
the asymmetry that we saw within the

1285
00:50:06,150 --> 00:50:04,160
data so we'll take our best fit solution

1286
00:50:11,109 --> 00:50:06,160
the black solid black line here and use

1287
00:50:15,670 --> 00:50:12,870
if we combine all of those data's and

1288
00:50:17,750 --> 00:50:15,680

curve we can import them into our

1289
00:50:20,150 --> 00:50:17,760
guiding equation and then next we can

1290
00:50:23,270 --> 00:50:20,160
think about how is

1291
00:50:26,230 --> 00:50:23,280
elevation going to be related to the

1292
00:50:27,510 --> 00:50:26,240
amount of surface area that it composes

1293
00:50:29,750 --> 00:50:27,520
on a planet

1294
00:50:31,510 --> 00:50:29,760
well this is where hypsometry comes in

1295
00:50:33,349 --> 00:50:31,520
and hypsometry is the science of

1296
00:50:35,990 --> 00:50:33,359
measuring the elevation and depth

1297
00:50:37,829 --> 00:50:36,000
features on a planet's surface with

1298
00:50:39,829 --> 00:50:37,839
respect to sea level

1299
00:50:41,750 --> 00:50:39,839
if you're unfamiliar with hypsometry

1300
00:50:43,589 --> 00:50:41,760
here's the hyposymmetric curve of earth

1301
00:50:45,589 --> 00:50:43,599
it's showing the cumulative area on the

1302
00:50:48,069 --> 00:50:45,599
horizontal axis with zero on the left

1303
00:50:49,829 --> 00:50:48,079
and 100 on the right and elevation on

1304
00:50:51,510 --> 00:50:49,839
the vertical axis showing that the

1305
00:50:53,910 --> 00:50:51,520
deepest points are down around 10

1306
00:50:55,430 --> 00:50:53,920
kilometers and the highest between seven

1307
00:50:57,190 --> 00:50:55,440
and eight kilometers

1308
00:50:59,270 --> 00:50:57,200
this is showing from moving from left to

1309
00:51:02,069 --> 00:50:59,280
right mountains which do not compose a

1310
00:51:04,470 --> 00:51:02,079
large cumulative area into the

1311
00:51:06,150 --> 00:51:04,480
continental plains which are making up

1312
00:51:08,069 --> 00:51:06,160
the vast majority of our exposed

1313
00:51:09,910 --> 00:51:08,079

continents and then as you move below

1314
00:51:11,910 --> 00:51:09,920
sea level you have continental shelf and

1315
00:51:13,990 --> 00:51:11,920
slope followed by

1316
00:51:15,829 --> 00:51:14,000
the abyssal plains which compose the

1317
00:51:17,910 --> 00:51:15,839
majority of the ocean basins and then

1318
00:51:20,390 --> 00:51:17,920
moving into the trenches

1319
00:51:22,790 --> 00:51:20,400
each of these features can be related to

1320
00:51:25,190 --> 00:51:22,800
underlying mantle convection

1321
00:51:26,710 --> 00:51:25,200
here's a cartoon of that mantle

1322
00:51:28,870 --> 00:51:26,720
convection here i'm assuming the

1323
00:51:31,030 --> 00:51:28,880
operation of plate tectonics different

1324
00:51:33,430 --> 00:51:31,040
from what rudy was just assuming in the

1325
00:51:34,950 --> 00:51:33,440
operation of a stagnant lead planet

1326
00:51:37,109 --> 00:51:34,960
now to actually show you where this

1327
00:51:40,870 --> 00:51:37,119
cross section is located i have the

1328
00:51:43,030 --> 00:51:40,880
figures on the left that showing a a

1329
00:51:47,030 --> 00:51:43,040
representative location

1330
00:51:49,270 --> 00:51:47,040
off the west coast of of south america

1331
00:51:51,030 --> 00:51:49,280
and what's occurring in this cartoon is

1332
00:51:52,069 --> 00:51:51,040
that you have mantle convection that's

1333
00:51:53,829 --> 00:51:52,079
occurring

1334
00:51:55,349 --> 00:51:53,839
within the interior of the planet and

1335
00:51:57,349 --> 00:51:55,359
its role is to

1336
00:51:59,910 --> 00:51:57,359
eliminate the heat that's produced due

1337
00:52:02,150 --> 00:51:59,920
to the decay of radiogenic elements

1338
00:52:03,990 --> 00:52:02,160

now as the rock is in motion

1339
00:52:07,190 --> 00:52:04,000
warmer rock is being brought to the

1340
00:52:09,990 --> 00:52:07,200
surface and it's producing melt this

1341
00:52:11,990 --> 00:52:10,000
melt is generating new plate and as that

1342
00:52:13,510 --> 00:52:12,000
plate moves away from the plate boundary

1343
00:52:16,630 --> 00:52:13,520
the spreading center which is indicated

1344
00:52:19,430 --> 00:52:16,640
by these red blobs the plate cools as it

1345
00:52:22,790 --> 00:52:19,440
cools it thickens and becomes uh

1346
00:52:25,270 --> 00:52:22,800
less buoyant and therefore it subsides

1347
00:52:27,270 --> 00:52:25,280
it continues to do this until it reaches

1348
00:52:28,630 --> 00:52:27,280
the boundary the the other plate

1349
00:52:30,630 --> 00:52:28,640
boundary which is going to be a

1350
00:52:33,030 --> 00:52:30,640
subduction zone now at this plate

1351
00:52:35,190 --> 00:52:33,040
boundary you have the convergence of two

1352
00:52:37,910 --> 00:52:35,200
plates the resulting behavior is that

1353
00:52:39,829 --> 00:52:37,920
you have an increase you have a

1354
00:52:41,430 --> 00:52:39,839
production of mountains which we can

1355
00:52:42,870 --> 00:52:41,440
model and estimate how high those

1356
00:52:44,950 --> 00:52:42,880
mountains are

1357
00:52:47,670 --> 00:52:44,960
so we can take and incorporate these

1358
00:52:50,069 --> 00:52:47,680
aspects into a model to help us to

1359
00:52:52,150 --> 00:52:50,079
estimate what the hypometry is of a

1360
00:52:54,069 --> 00:52:52,160
planet the steps that you go through to

1361
00:52:55,990 --> 00:52:54,079
calculate this is understanding its the

1362
00:52:58,069 --> 00:52:56,000
mantle thermal history that's going to

1363
00:53:00,630 --> 00:52:58,079

feed into a calculation of both plate

1364
00:53:01,829 --> 00:53:00,640
velocities as well as oceanic crustal

1365
00:53:03,750 --> 00:53:01,839
thickness

1366
00:53:05,030 --> 00:53:03,760
that the velocity and the crustal

1367
00:53:06,710 --> 00:53:05,040
thickness we're going to relate to

1368
00:53:09,430 --> 00:53:06,720
mountain height and then that's going to

1369
00:53:11,430 --> 00:53:09,440
feed into our calculation of his

1370
00:53:13,030 --> 00:53:11,440
symmetric curves

1371
00:53:15,190 --> 00:53:13,040
so if we go through and show a

1372
00:53:17,670 --> 00:53:15,200
representative case that we've done for

1373
00:53:20,150 --> 00:53:17,680
earth the modeled uh value is on the

1374
00:53:21,349 --> 00:53:20,160
left and the actual value is on the

1375
00:53:23,349 --> 00:53:21,359
right

1376
00:53:25,510 --> 00:53:23,359
the difference in the curvature is that

1377
00:53:28,390 --> 00:53:25,520
uh on the left model i've kept it in

1378
00:53:31,190 --> 00:53:28,400
terms of how i presented the

1379
00:53:33,030 --> 00:53:31,200
geological setting if you were to flip

1380
00:53:35,349 --> 00:53:33,040
the abyssal plane so

1381
00:53:36,790 --> 00:53:35,359
the um uh

1382
00:53:39,910 --> 00:53:36,800
result from subsidence of the

1383
00:53:41,670 --> 00:53:39,920
lithosphere um from left to right you

1384
00:53:43,030 --> 00:53:41,680
would get a similar type of curve that

1385
00:53:44,870 --> 00:53:43,040
you see on the right and we are

1386
00:53:47,430 --> 00:53:44,880
capturing the general trends as well as

1387
00:53:49,430 --> 00:53:47,440
the uh general values

1388
00:53:51,270 --> 00:53:49,440

so we can take and plug this into our to

1389
00:53:53,589 --> 00:53:51,280
our larger model and then we can ask

1390
00:53:56,309 --> 00:53:53,599
ourselves does this model even work for

1391
00:53:58,790 --> 00:53:56,319
earth well if we try to calculate the

1392
00:54:00,230 --> 00:53:58,800
number of terrestrial vertebrate species

1393
00:54:02,230 --> 00:54:00,240
from our model

1394
00:54:04,390 --> 00:54:02,240
we estimate there's twenty thousand five

1395
00:54:06,630 --> 00:54:04,400
hundred the actual value is somewhere

1396
00:54:08,790 --> 00:54:06,640
around twenty one thousand so we're at

1397
00:54:11,910 --> 00:54:08,800
least within the ballpark good enough

1398
00:54:12,630 --> 00:54:11,920
for the remainder analysis of our work

1399
00:54:14,309 --> 00:54:12,640
so

1400
00:54:17,670 --> 00:54:14,319
what we'd like to do now having this

1401
00:54:20,150 --> 00:54:17,680
calibrated for earth is extended to uh

1402
00:54:22,390 --> 00:54:20,160
planets larger and smaller than earth

1403
00:54:24,230 --> 00:54:22,400
now to do this requires that we make

1404
00:54:26,390 --> 00:54:24,240
some modifications to our mental thermal

1405
00:54:29,670 --> 00:54:26,400
history model so we're going to account

1406
00:54:31,430 --> 00:54:29,680
for how the mental thermal evolution

1407
00:54:33,589 --> 00:54:31,440
occurs over four and a half billion

1408
00:54:35,910 --> 00:54:33,599
years until present day and then we're

1409
00:54:39,430 --> 00:54:35,920
going to compare the hypsometries for

1410
00:54:41,030 --> 00:54:39,440
different mass planets at present day

1411
00:54:42,789 --> 00:54:41,040
calculating that thermal history will

1412
00:54:45,109 --> 00:54:42,799
propagate to the rest of the model and

1413
00:54:46,630 --> 00:54:45,119

give us those hypsometric curves

1414
00:54:49,510 --> 00:54:46,640
rather than show you individual hip

1415
00:54:51,430 --> 00:54:49,520
solumetries i'll take a moment to step

1416
00:54:53,349 --> 00:54:51,440
through what i think are some

1417
00:54:54,789 --> 00:54:53,359
interesting aspects of those

1418
00:54:56,470 --> 00:54:54,799
hypsometries

1419
00:54:58,309 --> 00:54:56,480
what i'm showing on the left is maximum

1420
00:55:01,030 --> 00:54:58,319
elevation what i'm showing on the right

1421
00:55:03,349 --> 00:55:01,040
is exposed lamb fraction

1422
00:55:04,710 --> 00:55:03,359
in terms of maximum elevation notice

1423
00:55:07,109 --> 00:55:04,720
that this line

1424
00:55:11,430 --> 00:55:07,119
here is representing sea level

1425
00:55:13,589 --> 00:55:11,440
whereas on the right is showing the um

1426
00:55:15,190 --> 00:55:13,599
whereas on the right is showing the uh

1427
00:55:17,190 --> 00:55:15,200
the red line represents the lamp

1428
00:55:19,589 --> 00:55:17,200
fraction of earth notice that the

1429
00:55:21,510 --> 00:55:19,599
maximum elevations on the left

1430
00:55:24,309 --> 00:55:21,520
are

1431
00:55:25,990 --> 00:55:24,319
for

1432
00:55:28,069 --> 00:55:26,000
planets with smaller masses and they

1433
00:55:29,109 --> 00:55:28,079
decrease as you increase the planetary

1434
00:55:31,510 --> 00:55:29,119
mass

1435
00:55:34,069 --> 00:55:31,520
and then the surface area or the exposed

1436
00:55:37,109 --> 00:55:34,079
land fraction decreases as you increase

1437
00:55:41,109 --> 00:55:39,270
so how does this uh how does the number

1438
00:55:43,990 --> 00:55:41,119

of terrestrial vertebrates

1439
00:55:45,990 --> 00:55:44,000
vary with planetary mass

1440
00:55:48,150 --> 00:55:46,000
well if we combine all this together

1441
00:55:50,309 --> 00:55:48,160
what we're seeing is that the relative

1442
00:55:53,829 --> 00:55:50,319
number of vertebrate species is much

1443
00:55:56,069 --> 00:55:53,839
higher for planets of uh

1444
00:55:57,990 --> 00:55:56,079
of low mass planets than high mass

1445
00:56:00,470 --> 00:55:58,000
planets in fact there's three to four

1446
00:56:01,990 --> 00:56:00,480
times uh as many

1447
00:56:04,150 --> 00:56:02,000
terrestrial vertebrate species on

1448
00:56:05,589 --> 00:56:04,160
smaller planets and larger ones

1449
00:56:07,589 --> 00:56:05,599
what i would like to do is offer a

1450
00:56:09,910 --> 00:56:07,599
caution though that

1451
00:56:12,230 --> 00:56:09,920
there's little in the way of path

1452
00:56:14,390 --> 00:56:12,240
dependence of life within this model so

1453
00:56:16,470 --> 00:56:14,400
we've taken the only planet that we know

1454
00:56:18,309 --> 00:56:16,480
of life which is earth and extrapolated

1455
00:56:20,150 --> 00:56:18,319
that to every other planet

1456
00:56:22,230 --> 00:56:20,160
also there are other planetary cooling

1457
00:56:24,069 --> 00:56:22,240
regimes such as stagnant lid which we

1458
00:56:26,470 --> 00:56:24,079
just talked about this itself is going

1459
00:56:27,750 --> 00:56:26,480
to affect the hypsometry that would be

1460
00:56:29,349 --> 00:56:27,760
calculated

1461
00:56:31,349 --> 00:56:29,359
and then on top of that we need to think

1462
00:56:32,870 --> 00:56:31,359
about the water cycling so

1463
00:56:34,789 --> 00:56:32,880

how much water we assume is at the

1464
00:56:37,589 --> 00:56:34,799
surface of the different planets is

1465
00:56:39,430 --> 00:56:37,599
going to influence the amount of exposed

1466
00:56:41,510 --> 00:56:39,440
surface area

1467
00:56:48,309 --> 00:56:41,520
with that i'll take any questions thank

1468
00:57:03,190 --> 00:56:50,150
great thank you johnny

1469
00:57:12,230 --> 00:57:07,430
hi abel mendez from psja wpr civil

1470
00:57:13,030 --> 00:57:12,240
uh johnny great talk and i wonder about

1471
00:57:14,870 --> 00:57:13,040
uh

1472
00:57:17,510 --> 00:57:14,880
what you say about the scales of the

1473
00:57:19,910 --> 00:57:17,520
mountain usually that's because you have

1474
00:57:21,030 --> 00:57:19,920
more precipitation in those mountains so

1475
00:57:22,950 --> 00:57:21,040
you have

1476
00:57:25,589 --> 00:57:22,960
typically rainforests

1477
00:57:27,990 --> 00:57:25,599
but what would be the diversity for us

1478
00:57:29,430 --> 00:57:28,000
compared to other rainforests that are

1479
00:57:32,150 --> 00:57:29,440
not that high

1480
00:57:33,030 --> 00:57:32,160
or the other location that

1481
00:57:35,670 --> 00:57:33,040
doesn't

1482
00:57:38,950 --> 00:57:35,680
that are flat relative to

1483
00:57:40,710 --> 00:57:38,960
to sorry sorry i think uh if i'm

1484
00:57:41,670 --> 00:57:40,720
understanding it correctly you're asking

1485
00:57:43,589 --> 00:57:41,680
why

1486
00:57:45,030 --> 00:57:43,599
these smaller planets ended up having

1487
00:57:47,270 --> 00:57:45,040
higher mountains in

1488
00:57:51,109 --> 00:57:47,280

uh larger planets is that correct

1489
00:57:53,109 --> 00:57:51,119
i'm more into the biology more into

1490
00:57:58,950 --> 00:57:53,119
that scale

1491
00:58:00,789 --> 00:57:58,960
applying to other forests on on land

1492
00:58:02,870 --> 00:58:00,799
that are not that high

1493
00:58:04,710 --> 00:58:02,880
yeah i understand um

1494
00:58:07,349 --> 00:58:04,720
okay so one thing that we didn't take

1495
00:58:09,430 --> 00:58:07,359
into account is how the diversity how

1496
00:58:11,430 --> 00:58:09,440
the species richness is going to vary of

1497
00:58:13,349 --> 00:58:11,440
course in in those planes as we don't

1498
00:58:15,349 --> 00:58:13,359
have that constrained within this model

1499
00:58:18,230 --> 00:58:15,359
this was more looking at the effects of

1500
00:58:20,230 --> 00:58:18,240
changes in elevation than that so yes

1501
00:58:22,789 --> 00:58:20,240
that would be something that would be

1502
00:58:25,430 --> 00:58:22,799
important to incorporate in in future

1503
00:58:26,710 --> 00:58:25,440
generations of the model

1504
00:58:29,190 --> 00:58:26,720
perfect thank you

1505
00:58:34,829 --> 00:58:29,200
thank you abel

1506
00:58:40,390 --> 00:58:38,309
questions okay i actually have one um

1507
00:58:41,829 --> 00:58:40,400
sure this is stephanie olson from uh

1508
00:58:43,430 --> 00:58:41,839
purdue

1509
00:58:45,670 --> 00:58:43,440
and i know you were specifically

1510
00:58:47,990 --> 00:58:45,680
assuming uh the presence of plate

1511
00:58:51,109 --> 00:58:48,000
tectonics um but i'm i'm wondering if

1512
00:58:53,589 --> 00:58:51,119
you could comment on what your work

1513
00:58:54,789 --> 00:58:53,599

might imply for a stagnant lid planet

1514
00:58:56,390 --> 00:58:54,799
and the

1515
00:58:59,910 --> 00:58:56,400
diversity and complexity of life that

1516
00:59:05,990 --> 00:59:04,309
so that's going to i think uh

1517
00:59:08,390 --> 00:59:06,000
we don't really have a good idea the

1518
00:59:09,670 --> 00:59:08,400
hypsometries of stagnant lid planets

1519
00:59:11,270 --> 00:59:09,680
that's going to change things

1520
00:59:12,789 --> 00:59:11,280
drastically because the size of the

1521
00:59:14,950 --> 00:59:12,799
mountains that are produced on the plate

1522
00:59:17,190 --> 00:59:14,960
tectonic planets are going to be due to

1523
00:59:19,589 --> 00:59:17,200
collisions of plates which is going to

1524
00:59:21,670 --> 00:59:19,599
set your your actual height whereas for

1525
00:59:23,109 --> 00:59:21,680
stagnant lid planets you are going to

1526
00:59:24,390 --> 00:59:23,119
get mountains that are produced as i

1527
00:59:26,549 --> 00:59:24,400
showed with mars right that's the

1528
00:59:28,230 --> 00:59:26,559
largest mountain in the solar system but

1529
00:59:31,829 --> 00:59:28,240
those are through different processes

1530
00:59:33,589 --> 00:59:31,839
such as uh volcanism right so the

1531
00:59:37,190 --> 00:59:33,599
dominant driver of elevation and

1532
00:59:41,430 --> 00:59:37,200
topography is more going to be due to

1533
00:59:43,109 --> 00:59:41,440
the uh volcanics than the uh collision

1534
00:59:44,870 --> 00:59:43,119
of plates so you have to go through and

1535
00:59:47,430 --> 00:59:44,880
be able to understand how that's going

1536
00:59:50,470 --> 00:59:47,440
to change as a function of mantle

1537
00:59:51,990 --> 00:59:50,480
temperature and planetary size

1538
00:59:55,140 --> 00:59:52,000

great thank you

1539
01:00:00,230 --> 00:59:55,150
yeah thank you thank johnny again

1540
01:00:05,670 --> 01:00:03,990
so our next um presentation actually was

1541
01:00:08,390 --> 01:00:05,680
withdrawn

1542
01:00:11,430 --> 01:00:08,400
and so we will have um

1543
01:00:12,870 --> 01:00:11,440
15 bonus minutes uh before our next

1544
01:00:14,150 --> 01:00:12,880
speaker

1545
01:00:16,789 --> 01:00:14,160
um so i thought we could take this

1546
01:00:18,870 --> 01:00:16,799
opportunity to ask uh any questions that

1547
01:00:20,150 --> 01:00:18,880
you might have of our first uh four

1548
01:00:21,910 --> 01:00:20,160
speakers i know that there were some

1549
01:00:23,510 --> 01:00:21,920
questions for rudy that we didn't have a

1550
01:00:27,430 --> 01:00:23,520
chance to get to

1551
01:00:27,440 --> 01:00:32,950
all right come on up to the microphone

1552
01:00:38,069 --> 01:00:35,430
hi arnold salvador from northern arizona

1553
01:00:41,829 --> 01:00:38,079
university uh i was wondering about the

1554
01:00:42,950 --> 01:00:41,839
venus evolutionary scenarios what are

1555
01:00:44,390 --> 01:00:42,960
the

1556
01:00:47,349 --> 01:00:44,400
actual initial

1557
01:00:49,670 --> 01:00:47,359
wire content considered in the model and

1558
01:00:51,510 --> 01:00:49,680
how this could influence the results and

1559
01:00:55,270 --> 01:00:51,520
the pathways

1560
01:00:58,470 --> 01:00:56,950
hello yeah that's uh that's a good

1561
01:01:00,549 --> 01:00:58,480
question you know so our initial

1562
01:01:03,270 --> 01:01:00,559
conditions for water are uh

1563
01:01:04,789 --> 01:01:03,280

between two and ten terrestrial oceans

1564
01:01:07,030 --> 01:01:04,799
uh that venus formed with so it's kind

1565
01:01:08,950 --> 01:01:07,040
of based on some of sean raymond's work

1566
01:01:10,390 --> 01:01:08,960
on like how much water did earth and

1567
01:01:11,990 --> 01:01:10,400
venus start with

1568
01:01:12,870 --> 01:01:12,000
um and then

1569
01:01:14,230 --> 01:01:12,880
we

1570
01:01:16,390 --> 01:01:14,240
that's one parameter and actually

1571
01:01:17,430 --> 01:01:16,400
another parameter is how is that water

1572
01:01:22,710 --> 01:01:17,440
uh

1573
01:01:25,109 --> 01:01:22,720
goes between 50 in the mantle all the

1574
01:01:27,190 --> 01:01:25,119
way up to 90 initially the mantle and

1575
01:01:29,349 --> 01:01:27,200
interestingly enough the simulations

1576
01:01:30,789 --> 01:01:29,359
that have a high initial water content

1577
01:01:33,829 --> 01:01:30,799
especially in the mantle those

1578
01:01:35,829 --> 01:01:33,839
simulations really match venus and below

1579
01:01:38,549 --> 01:01:35,839
a formation of about

1580
01:01:40,470 --> 01:01:38,559
four terrestrial oceans in the mantle um

1581
01:01:43,589 --> 01:01:40,480
we didn't get any scenarios that

1582
01:01:45,430 --> 01:01:43,599
actually reproduced modern day venus

1583
01:01:47,589 --> 01:01:45,440
and then just a little question what

1584
01:01:50,150 --> 01:01:47,599
about the time scale then to if you have

1585
01:01:52,309 --> 01:01:50,160
a large amount of water in the mantle uh

1586
01:01:54,950 --> 01:01:52,319
to lose that water and reach the current

1587
01:01:56,950 --> 01:01:54,960
uh atmospheric water content on venus

1588
01:01:58,309 --> 01:01:56,960

what's the time scale for that yeah so

1589
01:01:59,270 --> 01:01:58,319
that actually happens pretty quickly

1590
01:02:00,150 --> 01:01:59,280
it's about

1591
01:02:01,990 --> 01:02:00,160
uh

1592
01:02:03,990 --> 01:02:02,000
like on on the order of like tens of

1593
01:02:06,150 --> 01:02:04,000
millions of years so it's like a really

1594
01:02:08,470 --> 01:02:06,160
very steep drop and then it gets kind of

1595
01:02:10,789 --> 01:02:08,480
maintained and outgassing after that

1596
01:02:12,230 --> 01:02:10,799
like initial okay we're gonna lose

1597
01:02:14,390 --> 01:02:12,240
basically everything in that atmosphere

1598
01:02:16,789 --> 01:02:14,400
really quickly um because atmospheric

1599
01:02:18,470 --> 01:02:16,799
escape tends to scale at least in our

1600
01:02:20,390 --> 01:02:18,480
model with the amount of water in the

1601
01:02:22,069 --> 01:02:20,400
atmosphere um

1602
01:02:24,230 --> 01:02:22,079
after that it hits this kind of like

1603
01:02:25,589 --> 01:02:24,240
kind of steady state where outgassing

1604
01:02:27,270 --> 01:02:25,599
and atmospheric escape balance each

1605
01:02:28,549 --> 01:02:27,280
other but that's not you know

1606
01:02:29,990 --> 01:02:28,559
uh

1607
01:02:31,510 --> 01:02:30,000
it doesn't always have to hit a steady

1608
01:02:35,829 --> 01:02:31,520
state

1609
01:02:43,510 --> 01:02:37,829
any questions for any of our other

1610
01:02:46,789 --> 01:02:45,670
so we also have a poster session right

1611
01:02:50,150 --> 01:02:46,799
after this

1612
01:02:52,470 --> 01:02:50,160
talk at 4 30 are there any poster

1613
01:02:54,870 --> 01:02:52,480

presenters here who want to just say a

1614
01:03:05,829 --> 01:02:54,880
couple words about their posters

1615
01:03:10,870 --> 01:03:07,670
i'll volunteer so that jonathan doesn't

1616
01:03:12,630 --> 01:03:10,880
feel left out um so hi i'm emily laflesh

1617
01:03:15,190 --> 01:03:12,640
from purdue university um i'll be

1618
01:03:16,870 --> 01:03:15,200
presenting my poster today um it's

1619
01:03:18,549 --> 01:03:16,880
called modeling nitrogen cycle

1620
01:03:20,309 --> 01:03:18,559
seasonality on early earth and

1621
01:03:22,710 --> 01:03:20,319
earth-like exoplanets

1622
01:03:24,390 --> 01:03:22,720
um i guess to give a very very short

1623
01:03:26,230 --> 01:03:24,400
synopsis of this

1624
01:03:29,109 --> 01:03:26,240
we noticed that oxygen has a pretty

1625
01:03:31,190 --> 01:03:29,119
significant seasonal cycle and we also

1626
01:03:33,910 --> 01:03:31,200
know that oxygen has a very

1627
01:03:36,150 --> 01:03:33,920
strong impact um on biological

1628
01:03:37,990 --> 01:03:36,160
productivity and so

1629
01:03:40,549 --> 01:03:38,000
that will be explained more in detail

1630
01:03:42,150 --> 01:03:40,559
when you come see my poster hopefully

1631
01:03:43,829 --> 01:03:42,160
but we wanted to know if the nitrogen

1632
01:03:46,950 --> 01:03:43,839
cycle which is strongly biologically

1633
01:03:49,990 --> 01:03:46,960
modulated is affected by this oxygen

1634
01:03:52,309 --> 01:03:50,000
seasonality and in fact it is so i will

1635
01:03:54,150 --> 01:03:52,319
be explaining kind of the way in which

1636
01:03:57,029 --> 01:03:54,160
nitrogen or the nitrogen cycle is

1637
01:03:59,270 --> 01:03:57,039
affected by seasonality and how we might

1638
01:03:59,990 --> 01:03:59,280

be able to extrapolate that information

1639
01:04:02,069 --> 01:04:00,000
to

1640
01:04:04,630 --> 01:04:02,079
biosignatures and

1641
01:04:06,950 --> 01:04:04,640
detectability on exoplanets so hope to

1642
01:04:11,589 --> 01:04:06,960
see you there

1643
01:04:17,910 --> 01:04:13,990
i'm not biased at all but emily's poster

1644
01:04:23,510 --> 01:04:20,789
um there is also uh another really

1645
01:04:25,430 --> 01:04:23,520
fantastic poster at our at our poster

1646
01:04:28,470 --> 01:04:25,440
session about

1647
01:04:31,670 --> 01:04:28,480
um the habitability of high obliquity

1648
01:04:33,270 --> 01:04:31,680
worlds and high eccentricity worlds too

1649
01:04:34,549 --> 01:04:33,280
and really intriguingly the combination

1650
01:04:36,549 --> 01:04:34,559
of really high obliquity and high

1651
01:04:38,630 --> 01:04:36,559
eccentricity uh

1652
01:04:41,589 --> 01:04:38,640
my naive expectation was that that might

1653
01:04:44,470 --> 01:04:41,599
be stressful for life but life not only

1654
01:04:46,309 --> 01:04:44,480
you know did okay it actually thrived

1655
01:04:48,390 --> 01:04:46,319
uh and we were able to simulate more

1656
01:04:49,750 --> 01:04:48,400
productive biospheres than present-day

1657
01:04:51,750 --> 01:04:49,760
earth under what

1658
01:04:52,950 --> 01:04:51,760
i think are fairly extreme seasonal

1659
01:04:54,549 --> 01:04:52,960
conditions

1660
01:04:55,910 --> 01:04:54,559
so i'm very excited about that poster as

1661
01:04:57,589 --> 01:04:55,920
well

1662
01:05:00,630 --> 01:04:57,599
uh the

1663
01:05:02,549 --> 01:05:00,640

lead author on that is jonathan jernigan

1664
01:05:08,870 --> 01:05:02,559
over there in the audience so please

1665
01:05:13,910 --> 01:05:11,270
all right we have just about 10 minutes

1666
01:05:15,750 --> 01:05:13,920
until our next scheduled talk

1667
01:05:18,870 --> 01:05:15,760
um so how about everyone takes a moment

1668
01:05:20,630 --> 01:05:18,880
to get some more water uh

1669
01:13:11,830 --> 01:05:20,640
and chat with your friends about the

1670
01:13:31,110 --> 01:13:13,669
i know i was planning on putting emily

1671
01:13:31,120 --> 01:15:19,110
like babies

1672
01:15:25,910 --> 01:15:21,510
all right everyone let's reconvene for

1673
01:15:28,709 --> 01:15:25,920
our final very exciting talk

1674
01:15:30,229 --> 01:15:28,719
the last speaker of this session will be

1675
01:15:32,870 --> 01:15:30,239
austin ware

1676
01:15:34,470 --> 01:15:32,880
who will be talking about pairing a gcm

1677
01:15:47,110 --> 01:15:34,480
and bayesian framework to predict

1678
01:15:51,430 --> 01:15:49,110
hi everyone my name's austin ware i'm a

1679
01:15:53,270 --> 01:15:51,440
graduate student at arizona state and

1680
01:15:54,950 --> 01:15:53,280
yeah i'll talk about pairing a gcm basin

1681
01:15:57,590 --> 01:15:54,960
framework to predict habitable zone

1682
01:16:00,709 --> 01:15:57,600
evolution try to make it

1683
01:16:01,990 --> 01:16:00,719
under 12 minutes maybe

1684
01:16:03,430 --> 01:16:02,000
all right

1685
01:16:06,310 --> 01:16:03,440
so first let's talk about continuous

1686
01:16:08,310 --> 01:16:06,320
habitable zones and find what that is so

1687
01:16:10,550 --> 01:16:08,320
continuous capital zone or we'll be

1688
01:16:12,950 --> 01:16:10,560

referred to here as a chz

1689
01:16:14,790 --> 01:16:12,960
as the orbital area remaining tenuously

1690
01:16:16,229 --> 01:16:14,800
within the habitable zone for some

1691
01:16:18,390 --> 01:16:16,239
length of time

1692
01:16:20,630 --> 01:16:18,400
um and so yeah obviously as the star

1693
01:16:22,390 --> 01:16:20,640
evolves on the right here

1694
01:16:27,030 --> 01:16:22,400
and the luminosity increases the

1695
01:16:30,070 --> 01:16:27,040
habitable zone will slowly move outwards

1696
01:16:32,229 --> 01:16:30,080
right but how long is long enough so

1697
01:16:34,310 --> 01:16:32,239
like for a planet to reside within the

1698
01:16:36,709 --> 01:16:34,320
habitable zone because obviously we want

1699
01:16:38,310 --> 01:16:36,719
to give that planet enough time to

1700
01:16:42,390 --> 01:16:38,320
evolve life and have that life make a

1701
01:16:48,470 --> 01:16:45,750
and so for that we look to the to earth

1702
01:16:51,510 --> 01:16:48,480
and the great oxidation event as kind of

1703
01:16:53,350 --> 01:16:51,520
a conservative estimate of how long so

1704
01:16:56,229 --> 01:16:53,360
it occurred approximately two billion

1705
01:16:58,870 --> 01:16:56,239
years after the formation of earth

1706
01:17:00,790 --> 01:16:58,880
which you can see on the right here

1707
01:17:03,430 --> 01:17:00,800
and obviously led to a very significant

1708
01:17:05,350 --> 01:17:03,440
increase in oxygen in the atmosphere

1709
01:17:07,030 --> 01:17:05,360
that would be detectable

1710
01:17:09,270 --> 01:17:07,040
and so we use that as a

1711
01:17:10,550 --> 01:17:09,280
very conservative benchmark for how long

1712
01:17:14,709 --> 01:17:10,560
a planet should reside within the

1713
01:17:18,870 --> 01:17:15,910

but obviously you could look at other

1714
01:17:20,630 --> 01:17:18,880
things like methane

1715
01:17:23,750 --> 01:17:20,640
which would have made a detectable

1716
01:17:25,990 --> 01:17:23,760
impact a little bit before this

1717
01:17:27,750 --> 01:17:26,000
but yeah so then we redefined the chc as

1718
01:17:29,510 --> 01:17:27,760
the chc2

1719
01:17:33,030 --> 01:17:29,520
or the two giga year continuous

1720
01:17:37,910 --> 01:17:34,870
right and so we originally did this

1721
01:17:41,270 --> 01:17:37,920
using models from kaparabu at all 2013

1722
01:17:43,030 --> 01:17:41,280
2014 which used a 1d cloud-free climate

1723
01:17:45,270 --> 01:17:43,040
model to determine the habitable zone

1724
01:17:47,590 --> 01:17:45,280
boundaries

1725
01:17:50,310 --> 01:17:47,600
see that on the plot on the right here

1726
01:17:53,189 --> 01:17:50,320
and so we this is from the 2014 paper

1727
01:17:54,390 --> 01:17:53,199
and we use um three the three models

1728
01:17:57,590 --> 01:17:54,400
from that

1729
01:17:59,510 --> 01:17:57,600
for a 0.1 uh earth mass planet a one

1730
01:18:00,870 --> 01:17:59,520
earth mass planet and a five earth mass

1731
01:18:03,590 --> 01:18:00,880
planet

1732
01:18:06,470 --> 01:18:03,600
um but then there is also a fourth uh

1733
01:18:07,750 --> 01:18:06,480
habitable zone uh that is not shown here

1734
01:18:10,070 --> 01:18:07,760
um and that would be the optimistic

1735
01:18:13,669 --> 01:18:10,080
habitable zone and that just assumes a

1736
01:18:16,070 --> 01:18:13,679
recent venus inner edge and a early mars

1737
01:18:17,990 --> 01:18:16,080
outer edge assuming that they had liquid

1738
01:18:20,790 --> 01:18:18,000

water on them at one time

1739
01:18:23,110 --> 01:18:20,800
and they would fall just

1740
01:18:25,030 --> 01:18:23,120
further out of where you see venus here

1741
01:18:28,310 --> 01:18:25,040
for the inner edge and a little bit

1742
01:18:30,709 --> 01:18:28,320
further out of those um other habitable

1743
01:18:33,110 --> 01:18:30,719
outer habitable zone lines uh that you

1744
01:18:34,229 --> 01:18:33,120
see there

1745
01:18:36,550 --> 01:18:34,239
all right

1746
01:18:40,149 --> 01:18:36,560
and so these models go into our bayesian

1747
01:18:42,550 --> 01:18:40,159
model um to predict how

1748
01:18:44,550 --> 01:18:42,560
the probability that a radius around a

1749
01:18:46,310 --> 01:18:44,560
star

1750
01:18:50,229 --> 01:18:46,320
has remained within the habitable zone

1751
01:18:52,950 --> 01:18:50,239
for two billion years or longer

1752
01:18:54,390 --> 01:18:52,960
and so what goes into that first we have

1753
01:18:56,470 --> 01:18:54,400
our prior probability

1754
01:18:59,669 --> 01:18:56,480
that the orbital radius is within the

1755
01:19:01,910 --> 01:18:59,679
chc2 and so that combines um tycho

1756
01:19:04,630 --> 01:19:01,920
stellar evolution models with have the

1757
01:19:06,790 --> 01:19:04,640
habitable zone models

1758
01:19:09,910 --> 01:19:06,800
and then that gets paired with our

1759
01:19:12,310 --> 01:19:09,920
likelihood of the models given the

1760
01:19:14,310 --> 01:19:12,320
measured stellar mass metallicity and

1761
01:19:16,229 --> 01:19:14,320
age

1762
01:19:18,870 --> 01:19:16,239
and basically those two just get

1763
01:19:21,270 --> 01:19:18,880

multiplied together to get our posterior

1764
01:19:29,110 --> 01:19:21,280
likelihood or the probability of the

1765
01:19:34,870 --> 01:19:31,030
and so

1766
01:19:38,390 --> 01:19:34,880
our initial sample selection from my

1767
01:19:40,470 --> 01:19:38,400
paper i published this year uh we um

1768
01:19:43,510 --> 01:19:40,480
looked at earth-like rocky planets which

1769
01:19:46,870 --> 01:19:43,520
we define as those having a radius less

1770
01:19:49,830 --> 01:19:46,880
than 1.8 our earth and a mass less than

1771
01:19:51,510 --> 01:19:49,840
10 10 m earth

1772
01:19:54,149 --> 01:19:51,520
and we made sure they had installation

1773
01:19:57,990 --> 01:19:54,159
values within the optimistic um

1774
01:20:00,070 --> 01:19:58,000
copperapu 2013 limits

1775
01:20:02,870 --> 01:20:00,080
and they were around host stars between

1776
01:20:05,750 --> 01:20:02,880
0.5 and 1.1.1

1777
01:20:08,229 --> 01:20:05,760
solar masses which was that lower mat

1778
01:20:10,629 --> 01:20:08,239
mass limit is defined by the tycho

1779
01:20:12,950 --> 01:20:10,639
catalog lower limit for the evolution

1780
01:20:15,110 --> 01:20:12,960
models but we've updated that to go

1781
01:20:16,709 --> 01:20:15,120
lower now

1782
01:20:19,270 --> 01:20:16,719
and so we ended up with nine potentially

1783
01:20:21,110 --> 01:20:19,280
habitable planets plus venus earth and

1784
01:20:22,709 --> 01:20:21,120
mars and those nine potentially

1785
01:20:27,669 --> 01:20:22,719
habitable planets are on the right hand

1786
01:20:30,709 --> 01:20:28,629
and so

1787
01:20:31,910 --> 01:20:30,719
looking at the results from this initial

1788
01:20:34,149 --> 01:20:31,920

analysis

1789
01:20:35,510 --> 01:20:34,159
we have the sun on the left-hand side

1790
01:20:38,390 --> 01:20:35,520
here

1791
01:20:40,229 --> 01:20:38,400
and so on the y-axis is the probability

1792
01:20:43,350 --> 01:20:40,239
that a given orbital radius is within

1793
01:20:45,189 --> 01:20:43,360
the chc2 and on the x-axis is the

1794
01:20:47,189 --> 01:20:45,199
distance from the star

1795
01:20:48,790 --> 01:20:47,199
and so all the black lines you see there

1796
01:20:50,950 --> 01:20:48,800
are the different models from the copper

1797
01:20:52,550 --> 01:20:50,960
opera papers

1798
01:20:55,910 --> 01:20:52,560
and then the

1799
01:20:57,270 --> 01:20:55,920
colored bars are for the planetary

1800
01:21:01,910 --> 01:20:57,280
radii

1801
01:21:04,149 --> 01:21:01,920
and so uh we see that it for all of the

1802
01:21:06,629 --> 01:21:04,159
different models it gives venus a zero

1803
01:21:09,110 --> 01:21:06,639
percent chance of being within the chg-2

1804
01:21:10,870 --> 01:21:09,120
earth is given 100 chance for every

1805
01:21:13,350 --> 01:21:10,880
model except the most conservative one

1806
01:21:15,830 --> 01:21:13,360
which is the 0.1 earth mass model i mean

1807
01:21:17,830 --> 01:21:15,840
mars is actually given 100 chance for

1808
01:21:19,350 --> 01:21:17,840
all four models

1809
01:21:21,430 --> 01:21:19,360
and you'll notice that is very much like

1810
01:21:23,189 --> 01:21:21,440
a step function for the sun and that's

1811
01:21:25,189 --> 01:21:23,199
just because we have such a precise age

1812
01:21:26,790 --> 01:21:25,199
measurement for the sun that we know

1813
01:21:28,550 --> 01:21:26,800

really what

1814
01:21:31,189 --> 01:21:28,560
radii are still in the habitable zone

1815
01:21:32,870 --> 01:21:31,199
and which have left et cetera but then

1816
01:21:34,790 --> 01:21:32,880
if we move to an exoplanet on the

1817
01:21:36,149 --> 01:21:34,800
right-hand side here uh kep

1818
01:21:39,189 --> 01:21:36,159
oh sorry uh

1819
01:21:42,229 --> 01:21:39,199
another star uh on the right-hand side

1820
01:21:43,910 --> 01:21:42,239
side here uh kepler-442

1821
01:21:45,110 --> 01:21:43,920
we see that's much more like a gaussian

1822
01:21:46,470 --> 01:21:45,120
distribution

1823
01:21:48,310 --> 01:21:46,480
um

1824
01:21:51,110 --> 01:21:48,320
yeah because

1825
01:21:53,110 --> 01:21:51,120
ages for field stars are usually

1826
01:21:54,830 --> 01:21:53,120
have errors on the order about a billion

1827
01:21:56,870 --> 01:21:54,840
years or more

1828
01:21:58,550 --> 01:21:56,880
um yeah

1829
01:22:00,790 --> 01:21:58,560
all right and so those are just the

1830
01:22:03,189 --> 01:22:00,800
results from that initial analysis uh

1831
01:22:06,470 --> 01:22:03,199
with the 1d climate model

1832
01:22:08,470 --> 01:22:06,480
but we wanted to uh use results from a

1833
01:22:10,310 --> 01:22:08,480
general circulation model to compare to

1834
01:22:13,110 --> 01:22:10,320
that

1835
01:22:14,950 --> 01:22:13,120
and so we used results from the rocky 3d

1836
01:22:16,550 --> 01:22:14,960
land planets perturbed parameter

1837
01:22:17,830 --> 01:22:16,560
ensemble

1838
01:22:20,149 --> 01:22:17,840

and i'm not going to go into great

1839
01:22:22,229 --> 01:22:20,159
detail about what rocky 3d is and how it

1840
01:22:23,750 --> 01:22:22,239
works

1841
01:22:25,430 --> 01:22:23,760
but if you want to learn more about that

1842
01:22:27,350 --> 01:22:25,440
i would encourage you to go see nancy

1843
01:22:28,390 --> 01:22:27,360
kang's talk on friday

1844
01:22:29,830 --> 01:22:28,400
um

1845
01:22:33,189 --> 01:22:29,840
yeah but i'll talk a little bit about

1846
01:22:35,910 --> 01:22:33,199
the land planet's ensemble um so

1847
01:22:36,870 --> 01:22:35,920
yeah they used a latin hypercube design

1848
01:22:38,550 --> 01:22:36,880
um

1849
01:22:39,750 --> 01:22:38,560
again you can learn more about that on

1850
01:22:41,990 --> 01:22:39,760
friday

1851
01:22:43,830 --> 01:22:42,000
but basically they sampled nine

1852
01:22:45,510 --> 01:22:43,840
continuous variables such as the stellar

1853
01:22:47,990 --> 01:22:45,520
effect of temperature uh different

1854
01:22:49,990 --> 01:22:48,000
orbital properties like solar day

1855
01:22:52,550 --> 01:22:50,000
obliquity and

1856
01:22:55,189 --> 01:22:52,560
also altered things like the co2 content

1857
01:22:58,229 --> 01:22:55,199
the nurturing content and

1858
01:22:59,350 --> 01:22:58,239
a bunch of other things as well

1859
01:23:01,590 --> 01:22:59,360
yeah and so in the end they ended up

1860
01:23:03,990 --> 01:23:01,600
with 110 experiments

1861
01:23:07,270 --> 01:23:04,000
but after crashes and mistakes there

1862
01:23:09,750 --> 01:23:07,280
were about 84 final experiments

1863
01:23:13,350 --> 01:23:09,760

which still provided a robust sample of

1864
01:23:18,550 --> 01:23:16,229
all right and so the purpose of the land

1865
01:23:22,149 --> 01:23:18,560
planets ensemble oh i should mention

1866
01:23:25,110 --> 01:23:22,159
land planets are not ocean worlds or um

1867
01:23:27,910 --> 01:23:25,120
things like uh earth with oceans on them

1868
01:23:30,870 --> 01:23:27,920
it's uh a relatively dry planet with

1869
01:23:33,510 --> 01:23:30,880
just some lakes and soil moisture

1870
01:23:35,189 --> 01:23:33,520
um but yeah so the point of that was of

1871
01:23:36,790 --> 01:23:35,199
their land plants ensemble was to look

1872
01:23:38,950 --> 01:23:36,800
at the water inventories of these

1873
01:23:40,709 --> 01:23:38,960
planets and wasn't really to define

1874
01:23:42,310 --> 01:23:40,719
habitable zone boundaries so we had to

1875
01:23:43,430 --> 01:23:42,320
come up with a way to define those

1876
01:23:45,189 --> 01:23:43,440
boundaries

1877
01:23:46,709 --> 01:23:45,199
for this data

1878
01:23:48,550 --> 01:23:46,719
and so what we ended up doing for the

1879
01:23:51,110 --> 01:23:48,560
inner edge was

1880
01:23:53,430 --> 01:23:51,120
doing a linear regression

1881
01:23:55,110 --> 01:23:53,440
of the water lifetime

1882
01:23:56,550 --> 01:23:55,120
for these planets

1883
01:23:58,709 --> 01:23:56,560
and so we did a linear regression on the

1884
01:24:01,110 --> 01:23:58,719
observables of the infective temperature

1885
01:24:03,830 --> 01:24:01,120
of the stars and the stellar the

1886
01:24:06,390 --> 01:24:03,840
relative irradiance of the planets which

1887
01:24:09,110 --> 01:24:06,400
is information that we can get from our

1888
01:24:11,030 --> 01:24:09,120

stellar evolution models

1889
01:24:12,790 --> 01:24:11,040
and so we had to define a threshold for

1890
01:24:16,790 --> 01:24:12,800
what to consider

1891
01:24:18,390 --> 01:24:16,800
uh still habitable versus not and so

1892
01:24:20,149 --> 01:24:18,400
with water lifetime obviously that's

1893
01:24:22,070 --> 01:24:20,159
kind of undefined how long does water

1894
01:24:24,470 --> 01:24:22,080
need to last for something to remain

1895
01:24:26,229 --> 01:24:24,480
habitable um so we just went with an

1896
01:24:28,629 --> 01:24:26,239
extremely conservative

1897
01:24:30,950 --> 01:24:28,639
estimate that lined up with our

1898
01:24:32,790 --> 01:24:30,960
two giggy or tenuous habitable zone and

1899
01:24:35,270 --> 01:24:32,800
just said that the threshold for water

1900
01:24:37,110 --> 01:24:35,280
lifetime will be two billion years um

1901
01:24:39,910 --> 01:24:37,120
but you could obviously change this and

1902
01:24:41,030 --> 01:24:39,920
make this more or less conservative

1903
01:24:43,430 --> 01:24:41,040
uh

1904
01:24:45,990 --> 01:24:43,440
yeah and then so for the outer edge we

1905
01:24:47,350 --> 01:24:46,000
define that using the maximum mean

1906
01:24:49,030 --> 01:24:47,360
surface temperature

1907
01:24:51,510 --> 01:24:49,040
so basically looking for an area on the

1908
01:24:53,030 --> 01:24:51,520
planet akin to death valley that would

1909
01:24:55,830 --> 01:24:53,040
still have

1910
01:24:56,950 --> 01:24:55,840
an area that liquid water could exist

1911
01:25:00,390 --> 01:24:56,960
on

1912
01:25:03,110 --> 01:25:00,400
effect temperature and stellar and the

1913
01:25:05,350 --> 01:25:03,120

relative irradiance um and made our

1914
01:25:08,870 --> 01:25:05,360
threshold for surface temperature uh

1915
01:25:11,669 --> 01:25:10,550
all right so getting on to the results

1916
01:25:13,910 --> 01:25:11,679
from this

1917
01:25:16,470 --> 01:25:13,920
here again we have the sun

1918
01:25:18,709 --> 01:25:16,480
and the red

1919
01:25:21,590 --> 01:25:18,719
solid line indicates that the just using

1920
01:25:24,550 --> 01:25:21,600
the mean values from the regression

1921
01:25:27,350 --> 01:25:24,560
and then the dashed line is the

1922
01:25:28,870 --> 01:25:27,360
95 confidence interval

1923
01:25:30,229 --> 01:25:28,880
so because we don't input things like

1924
01:25:32,870 --> 01:25:30,239
the co2

1925
01:25:35,910 --> 01:25:32,880
um obliquity et cetera

1926
01:25:37,910 --> 01:25:35,920
we have errors on our coefficients from

1927
01:25:39,430 --> 01:25:37,920
the regression um and so we can

1928
01:25:40,629 --> 01:25:39,440
establish these confidence intervals

1929
01:25:42,709 --> 01:25:40,639
here

1930
01:25:45,669 --> 01:25:42,719
um yeah and so

1931
01:25:47,350 --> 01:25:45,679
for the sun uh we again project that

1932
01:25:49,830 --> 01:25:47,360
earth has a 100 chance of being in the

1933
01:25:52,709 --> 01:25:49,840
continuous habitable zone um but

1934
01:25:54,950 --> 01:25:52,719
actually venus and mars only have 100

1935
01:25:57,189 --> 01:25:54,960
chance once you consider that 95

1936
01:25:59,350 --> 01:25:57,199
confidence interval

1937
01:26:01,189 --> 01:25:59,360
um but then we can overlay the copper

1938
01:26:04,550 --> 01:26:01,199

wrapping models onto here it does get a

1939
01:26:07,510 --> 01:26:04,560
little messy but we can see that the

1940
01:26:08,470 --> 01:26:07,520
mean values from the rocky 3d model um

1941
01:26:13,110 --> 01:26:08,480
are

1942
01:26:14,870 --> 01:26:13,120
much tighter distribution than that from

1943
01:26:16,709 --> 01:26:14,880
the coparopo models

1944
01:26:18,790 --> 01:26:16,719
but then when we factor in the 95

1945
01:26:21,990 --> 01:26:18,800
confidence interval it becomes much more

1946
01:26:23,669 --> 01:26:22,000
optimistic than the 1d model

1947
01:26:25,750 --> 01:26:23,679
especially when you consider the inner

1948
01:26:27,990 --> 01:26:25,760
edge of the habitable zone it goes much

1949
01:26:29,910 --> 01:26:28,000
farther in

1950
01:26:31,669 --> 01:26:29,920
all right and then looking at kepler 442

1951
01:26:32,950 --> 01:26:31,679
here

1952
01:26:34,870 --> 01:26:32,960
the first thing you're going to notice

1953
01:26:36,629 --> 01:26:34,880
is that that outer edge is completely

1954
01:26:39,590 --> 01:26:36,639
unconstrained

1955
01:26:42,310 --> 01:26:39,600
and so the problem with using the data

1956
01:26:43,910 --> 01:26:42,320
from this land plant ensemble

1957
01:26:46,149 --> 01:26:43,920
is that because they weren't looking to

1958
01:26:48,390 --> 01:26:46,159
establish habitable zones

1959
01:26:50,629 --> 01:26:48,400
they also weren't looking to have their

1960
01:26:52,790 --> 01:26:50,639
planets freeze over

1961
01:26:54,950 --> 01:26:52,800
and so there was an extreme lack of

1962
01:26:57,750 --> 01:26:54,960
planets that reached extremely cold

1963
01:26:59,750 --> 01:26:57,760

temperatures ended up freezing over

1964
01:27:01,669 --> 01:26:59,760
and so that outer edge ended up

1965
01:27:04,470 --> 01:27:01,679
unconstrained

1966
01:27:07,110 --> 01:27:04,480
but the inner edge is constrained

1967
01:27:11,110 --> 01:27:07,120
and if we overlay the kapparapu models

1968
01:27:13,910 --> 01:27:11,120
here we'll again notice that the

1969
01:27:15,590 --> 01:27:13,920
rocky 3d model is shifted slightly

1970
01:27:17,669 --> 01:27:15,600
inwards

1971
01:27:20,149 --> 01:27:17,679
and for the

1972
01:27:24,790 --> 01:27:20,159
95 confidence interval it is again more

1973
01:27:27,590 --> 01:27:25,669
all right

1974
01:27:29,430 --> 01:27:27,600
but then so what i'm going to do here is

1975
01:27:31,669 --> 01:27:29,440
kind of step through

1976
01:27:33,669 --> 01:27:31,679
different stellar masses starting with

1977
01:27:36,390 --> 01:27:33,679
one of our smallest stars

1978
01:27:40,149 --> 01:27:36,400
and then getting to our largest star

1979
01:27:42,950 --> 01:27:40,159
and you'll notice that that outer edge

1980
01:27:46,310 --> 01:27:42,960
begins completely unconstrained for this

1981
01:27:48,709 --> 01:27:46,320
m1v star but then as we go up in mass it

1982
01:27:51,189 --> 01:27:48,719
slowly starts to come down

1983
01:27:54,149 --> 01:27:51,199
until it does become constrained

1984
01:27:55,270 --> 01:27:54,159
with kepler 4452 which is about a solar

1985
01:27:56,390 --> 01:27:55,280
mass star

1986
01:27:57,750 --> 01:27:56,400
um

1987
01:27:59,669 --> 01:27:57,760
yeah and so that just has to do with the

1988
01:28:04,070 --> 01:27:59,679

regression once it becomes a high enough

1989
01:28:06,310 --> 01:28:04,080
temperature and luminosity um it um

1990
01:28:08,950 --> 01:28:06,320
overpowers a negative value in our

1991
01:28:10,390 --> 01:28:08,960
regression um and becomes constrained

1992
01:28:12,470 --> 01:28:10,400
there

1993
01:28:15,110 --> 01:28:12,480
but yeah and then if we overlay the

1994
01:28:17,030 --> 01:28:15,120
copper optic models again we

1995
01:28:19,590 --> 01:28:17,040
see that for all of these different

1996
01:28:21,590 --> 01:28:19,600
models the um

1997
01:28:23,830 --> 01:28:21,600
rocky 3d values tend to be more

1998
01:28:27,030 --> 01:28:23,840
optimistic and the habitable zone tends

1999
01:28:29,110 --> 01:28:27,040
to be lifted shifted slightly inwards

2000
01:28:31,110 --> 01:28:29,120
um yeah

2001
01:28:33,270 --> 01:28:31,120
and so the reasoning for that are still

2002
01:28:35,110 --> 01:28:33,280
looking into uh but it is the common

2003
01:28:36,709 --> 01:28:35,120
trend we see

2004
01:28:38,870 --> 01:28:36,719
all right and so just some conclusions

2005
01:28:41,110 --> 01:28:38,880
here uh future ensembles should include

2006
01:28:43,189 --> 01:28:41,120
a wider range of installation values

2007
01:28:45,830 --> 01:28:43,199
obviously to account for this

2008
01:28:48,149 --> 01:28:45,840
unconstrained outer half of zone edge

2009
01:28:50,070 --> 01:28:48,159
the land planets ensemble habitable zone

2010
01:28:52,310 --> 01:28:50,080
boundaries are generally more optimistic

2011
01:28:54,070 --> 01:28:52,320
than the 1d model

2012
01:28:55,510 --> 01:28:54,080
and quantifying the uncertainty in

2013
01:28:57,910 --> 01:28:55,520

habits and boundaries allows us to

2014
01:28:59,750 --> 01:28:57,920
establish these con confidence intervals

2015
01:29:01,750 --> 01:28:59,760
and so i only showed the 95 percent one

2016
01:29:03,750 --> 01:29:01,760
here but you could

2017
01:29:06,709 --> 01:29:03,760
decide how conservative you want to be

2018
01:29:08,870 --> 01:29:06,719
and do like say a 50 confidence interval

2019
01:29:10,629 --> 01:29:08,880
interval or less

2020
01:29:12,709 --> 01:29:10,639
yeah and just the immediate next step

2021
01:29:13,990 --> 01:29:12,719
will be to expand the sample to include

2022
01:29:16,470 --> 01:29:14,000
all currently known potentially

2023
01:29:19,030 --> 01:29:16,480
habitable planets which we estimate to

2024
01:29:26,629 --> 01:29:19,040
be about 30.

2025
01:29:26,639 --> 01:29:31,590
thank you austin

2026
01:29:37,830 --> 01:29:35,110
does anyone have questions yes sorry

2027
01:29:40,310 --> 01:29:37,840
okay cool uh hi thank you for that talk

2028
01:29:42,629 --> 01:29:40,320
uh my name is evan davis uh university

2029
01:29:45,669 --> 01:29:42,639
of washington uh i noticed that you

2030
01:29:49,030 --> 01:29:45,679
included early type m dwarf stars uh in

2031
01:29:50,830 --> 01:29:49,040
your study uh but late-type vendor stars

2032
01:29:54,310 --> 01:29:50,840
are quite different

2033
01:29:56,229 --> 01:29:54,320
in stellar activity uh

2034
01:29:58,629 --> 01:29:56,239
goes on for much longer periods of time

2035
01:30:01,189 --> 01:29:58,639
so i was wondering uh did you have you

2036
01:30:02,870 --> 01:30:01,199
studied those yet in this work uh

2037
01:30:03,669 --> 01:30:02,880
and if not what do you think that would

2038
01:30:07,750 --> 01:30:03,679

do

2039
01:30:09,750 --> 01:30:07,760
uh yeah so uh as i so i showed a lot of

2040
01:30:11,189 --> 01:30:09,760
uh results some results from the

2041
01:30:13,750 --> 01:30:11,199
previous work we did with just the cop

2042
01:30:16,390 --> 01:30:13,760
wrapping models um and so at that time

2043
01:30:18,550 --> 01:30:16,400
we only had stellar um

2044
01:30:20,709 --> 01:30:18,560
cellular evolution models down to 0.5

2045
01:30:22,149 --> 01:30:20,719
solar masses um

2046
01:30:24,149 --> 01:30:22,159
and so

2047
01:30:27,430 --> 01:30:24,159
yeah we just began with those larger

2048
01:30:29,270 --> 01:30:27,440
stars i have now expanded it down to 0.2

2049
01:30:32,870 --> 01:30:29,280
solar masses and so we are going to get

2050
01:30:39,189 --> 01:30:32,880
into doing smaller stars yeah great

2051
01:30:39,199 --> 01:30:47,110
any further questions yes

2052
01:30:52,550 --> 01:30:50,390
um great very very interesting talk um

2053
01:30:54,229 --> 01:30:52,560
can you what what do you think is going

2054
01:30:56,070 --> 01:30:54,239
on with the inner edge

2055
01:30:57,830 --> 01:30:56,080
of the handball zone which

2056
01:31:01,110 --> 01:30:57,840
as you say is well

2057
01:31:03,030 --> 01:31:01,120
sampled in your grid and yet seems to be

2058
01:31:05,750 --> 01:31:03,040
producing a distinctively different

2059
01:31:08,149 --> 01:31:05,760
result than the 1d models

2060
01:31:09,830 --> 01:31:08,159
um is it something about

2061
01:31:11,189 --> 01:31:09,840
moist greenhouse i mean do you know i

2062
01:31:13,350 --> 01:31:11,199
don't know what is the physics that's

2063
01:31:14,950 --> 01:31:13,360

going that you think is might be leading

2064
01:31:17,350 --> 01:31:14,960
to that

2065
01:31:18,229 --> 01:31:17,360
yeah so we are a little early in this um

2066
01:31:19,910 --> 01:31:18,239
so

2067
01:31:21,189 --> 01:31:19,920
i haven't determined yet if maybe it

2068
01:31:23,030 --> 01:31:21,199
just has something to do with the fact

2069
01:31:24,149 --> 01:31:23,040
that i've decided to use the water

2070
01:31:26,470 --> 01:31:24,159
lifetime

2071
01:31:29,350 --> 01:31:26,480
um and that might be

2072
01:31:31,430 --> 01:31:29,360
you know deciding where that line is

2073
01:31:33,750 --> 01:31:31,440
but yeah

2074
01:31:36,070 --> 01:31:33,760
i don't know the exact reason why

2075
01:31:38,070 --> 01:31:36,080
it is shifted slightly inward right now

2076
01:31:39,590 --> 01:31:38,080
um but that is something i will

2077
01:31:42,870 --> 01:31:39,600
definitely get into as i start to write

2078
01:31:51,590 --> 01:31:44,790
all right let's thank austin and all of

2079
01:31:56,470 --> 01:31:53,590
and this is your final reminder that if

2080
01:31:58,390 --> 01:31:56,480
you like exoplanet habitability or

2081
01:32:00,149 --> 01:31:58,400
exoplanet bio signatures you should head