
AbSciCon
2017
MESA, ARIZONA

1
00:00:12,250 --> 00:00:06,150
you

2
00:00:19,090 --> 00:00:14,280
[Music]

3
00:00:21,670 --> 00:00:19,100
hello good afternoon as she said I'm

4
00:00:24,929 --> 00:00:21,680
Gila MonaVie and I'm filling in for Abed

5
00:00:29,439 --> 00:00:24,939
Mendez and presenting the results from

6
00:00:33,090 --> 00:00:29,449
the planetary habitability labs second

7
00:00:35,770 --> 00:00:33,100
earth-like worlds workshop where we

8
00:00:40,420 --> 00:00:35,780
studied habitability metrics for

9
00:00:44,220 --> 00:00:40,430
astrobiology if you like you can follow

10
00:00:51,610 --> 00:00:48,850
okay so what is a bit of habitability

11
00:00:55,270 --> 00:00:51,620
and how is it measured if we look at the

12
00:00:56,920 --> 00:00:55,280
map you can see that we have global

13
00:00:59,080 --> 00:00:56,930

terrestrial availability for primary

14
00:01:02,049 --> 00:00:59,090
producers as indicated by the net

15
00:01:05,859 --> 00:01:02,059
primary productivity and if you look at

16
00:01:07,810 --> 00:01:05,869
the equator you can see that the most

17
00:01:13,270 --> 00:01:07,820
productive areas or the most habitable

18
00:01:16,750 --> 00:01:13,280
areas are where we have forests okay so

19
00:01:18,690 --> 00:01:16,760
what is habitability habitability is the

20
00:01:21,219 --> 00:01:18,700
suitability of an environment for life

21
00:01:23,890 --> 00:01:21,229
it's formerly known as habitat

22
00:01:26,710 --> 00:01:23,900
suitability in biology specifically in

23
00:01:30,039 --> 00:01:26,720
ecology and habitability is usually

24
00:01:33,490 --> 00:01:30,049
quantified with indices that very very

25
00:01:36,609 --> 00:01:33,500
value from zero not habitable to one

26
00:01:38,320 --> 00:01:36,619
which is have oh these indices are an

27
00:01:41,190 --> 00:01:38,330
indication of the presence or abundance

28
00:01:43,960 --> 00:01:41,200
of some of the requirements of life a

29
00:01:45,490 --> 00:01:43,970
common misconception is that these

30
00:01:48,100 --> 00:01:45,500
indices need to consider all

31
00:01:51,969 --> 00:01:48,110
environmental factors to evaluate the

32
00:01:53,649 --> 00:01:51,979
habitability habitability is always

33
00:01:55,899 --> 00:01:53,659
evaluated by parts to understand

34
00:01:59,740 --> 00:01:55,909
individual contribution of one or more

35
00:02:02,530 --> 00:01:59,750
environmental factors and a library of

36
00:02:08,330 --> 00:02:02,540
indices is usually constructed to

37
00:02:15,050 --> 00:02:11,690
so we're presenting a general

38
00:02:17,180 --> 00:02:15,060

mass-energy habitability model current

39
00:02:19,940 --> 00:02:17,190
have ability models for example the

40
00:02:21,800 --> 00:02:19,950
habitat suitability model gives us a

41
00:02:24,260 --> 00:02:21,810
hability index that's proportional to

42
00:02:26,240 --> 00:02:24,270
the carrying capacity of an environment

43
00:02:28,550 --> 00:02:26,250
and so we get a numerical index that

44
00:02:30,050 --> 00:02:28,560
measures the capacity of the habitat to

45
00:02:33,880 --> 00:02:30,060
support a particular species or

46
00:02:36,589 --> 00:02:33,890
community our general mass-energy

47
00:02:39,020 --> 00:02:36,599
habitability model gives us a hability

48
00:02:42,559 --> 00:02:39,030
index that's proportional to the mass

49
00:02:44,809 --> 00:02:42,569
times energy that's available in a given

50
00:02:46,640 --> 00:02:44,819
environment so we get a numerical index

51
00:02:50,000 --> 00:02:46,650
that measures the mass energy capacity

52
00:02:54,229 --> 00:02:50,010
of a habitat to support life and how we

53
00:02:57,020 --> 00:02:54,239
get that index well we have to define a

54
00:02:59,660 --> 00:02:57,030
volume of interest and an amount of time

55
00:03:01,100 --> 00:02:59,670
we're going to watch that volume we

56
00:03:04,820 --> 00:03:01,110
measure the amount of energy going in

57
00:03:07,160 --> 00:03:04,830
and we measure the amount of gases of

58
00:03:13,360 --> 00:03:07,170
liquids and solids in that environment

59
00:03:16,340 --> 00:03:13,370
and that volume of interest and then we

60
00:03:18,920 --> 00:03:16,350
go ahead and make the calculation for

61
00:03:22,759 --> 00:03:18,930
the mass energy habitability index and

62
00:03:25,759 --> 00:03:22,769
here we have an example here we can see

63
00:03:29,090 --> 00:03:25,769

mass multiplied by energy and compared

64
00:03:31,160 --> 00:03:29,100
to a reference and this is how we get

65
00:03:35,059 --> 00:03:31,170
the mass part you can see it's a

66
00:03:39,259 --> 00:03:35,069
geometric mean of all of these masses by

67
00:03:41,780 --> 00:03:39,269
the way these masses do not include we

68
00:03:45,110 --> 00:03:41,790
don't include a biomass it's just the

69
00:03:48,170 --> 00:03:45,120
environment so we're using volumes and

70
00:03:49,759 --> 00:03:48,180
densities and the geometric mean and

71
00:03:51,949 --> 00:03:49,769
we're getting a normalized mass because

72
00:03:54,770 --> 00:03:51,959
we're comparing it to these reference

73
00:03:56,960 --> 00:03:54,780
values and this parts the energy and we

74
00:03:59,180 --> 00:03:56,970
can see that we're for this particular

75
00:04:03,940 --> 00:03:59,190
case we're using the temperature so

76
00:04:08,390 --> 00:04:03,950
we're talking about thermal energy and

77
00:04:10,370 --> 00:04:08,400
let's use that and so we have the mass

78
00:04:12,559 --> 00:04:10,380
energy availability index for some

79
00:04:17,650 --> 00:04:12,569
terrestrial environments now we're

80
00:04:24,950 --> 00:04:21,410
so again okay so we're considering for

81
00:04:26,030 --> 00:04:24,960
basic habitability elements we're

82
00:04:28,670 --> 00:04:26,040
considering the amount of gas

83
00:04:31,190 --> 00:04:28,680
represented by air the amount of liquid

84
00:04:32,960 --> 00:04:31,200
represented by water Livanos solid

85
00:04:36,080 --> 00:04:32,970
represented by earth and the amount of

86
00:04:38,600 --> 00:04:36,090
energy represented by fire so this is a

87
00:04:44,360 --> 00:04:38,610
little bit poetic but it's also somewhat

88
00:04:46,280 --> 00:04:44,370

accurate okay so our reference is the

89
00:04:49,400 --> 00:04:46,290
rainforest of El Yunque in Puerto Rico

90
00:04:52,150 --> 00:04:49,410
and since it's our reference it gets a

91
00:04:55,460 --> 00:04:52,160
mass energy habitability of exactly one

92
00:04:58,040 --> 00:04:55,470
now we're going to compare other biomes

93
00:05:01,580 --> 00:04:58,050
to that particular one and if we look at

94
00:05:04,900 --> 00:05:01,590
the ocean surface tropical we get a

95
00:05:08,210 --> 00:05:04,910
habitability value of 0.286 why so low

96
00:05:10,460 --> 00:05:08,220
well while in the rainforests we have

97
00:05:13,220 --> 00:05:10,470
lots of air lots of water lots of solids

98
00:05:15,470 --> 00:05:13,230
and lots of energy the ocean surface has

99
00:05:19,670 --> 00:05:15,480
lots of air lots of water lots of energy

100
00:05:21,170 --> 00:05:19,680
but not so much in solids and that solid

101
00:05:23,720 --> 00:05:21,180
you have there it's not that there is

102
00:05:25,520 --> 00:05:23,730
there aren't any solids in there you

103
00:05:27,440 --> 00:05:25,530
know but it's that it's a limiting

104
00:05:30,800 --> 00:05:27,450
factor there's little of that and so it

105
00:05:32,780 --> 00:05:30,810
drives the value down if we now go to

106
00:05:35,450 --> 00:05:32,790
the ocean depths you can see that the

107
00:05:37,250 --> 00:05:35,460
value is even lower well here what we

108
00:05:40,640 --> 00:05:37,260
have we have lots of water lots of

109
00:05:43,100 --> 00:05:40,650
solids but very little gases and very

110
00:05:44,600 --> 00:05:43,110
little energy so you get a lower value

111
00:05:48,530 --> 00:05:44,610
and if you go all the way to the clouds

112
00:05:51,290 --> 00:05:48,540
you get almost zero why lots of air lots

113
00:05:54,500 --> 00:05:51,300

of energy but compared to the small

114
00:05:57,560 --> 00:05:54,510
amounts of water and solids so those

115
00:06:00,560 --> 00:05:57,570
limiting factors are very important in

116
00:06:02,210 --> 00:06:00,570
bringing the values down but if you look

117
00:06:04,340 --> 00:06:02,220
at this more or less it seems reasonable

118
00:06:06,980 --> 00:06:04,350
you know more or less one woman what one

119
00:06:08,510 --> 00:06:06,990
would expect from these for this index

120
00:06:11,750 --> 00:06:08,520
and for what you would have for

121
00:06:16,190 --> 00:06:11,760
habitability comparing them but now

122
00:06:18,680 --> 00:06:16,200
let's see if this is actually valid so

123
00:06:21,650 --> 00:06:18,690
here we have a validation using

124
00:06:25,310 --> 00:06:21,660
terrestrial biomes what we did here is

125
00:06:28,130 --> 00:06:25,320
we compared the mass-energy hability it

126
00:06:29,600 --> 00:06:28,140
was calculated for each of those biomes

127
00:06:31,880 --> 00:06:29,610
again it was compared with the

128
00:06:34,180 --> 00:06:31,890
productivity the npp for 12 terrestrial

129
00:06:37,070 --> 00:06:34,190
biomes and you can see the data points

130
00:06:41,210 --> 00:06:37,080
okay and they make a nice little line

131
00:06:43,900 --> 00:06:41,220
there so this relation can now be used

132
00:06:47,120 --> 00:06:43,910
to predict the expected magnitude of

133
00:06:48,890 --> 00:06:47,130
biosignatures for example a higher

134
00:06:51,890 --> 00:06:48,900
global and PP means for more

135
00:06:56,090 --> 00:06:51,900
photosynthesis and thus more atmospheric

136
00:07:01,210 --> 00:06:56,100
oxygen produced okay so now we validated

137
00:07:04,610 --> 00:07:01,220
this let's try and apply it to planets

138
00:07:07,340 --> 00:07:04,620

now this is a model for an upper limit

139
00:07:10,160 --> 00:07:07,350
for planetary surface availability

140
00:07:12,560 --> 00:07:10,170
habitability and we assume that this is

141
00:07:15,110 --> 00:07:12,570
going to be for planets with a similar

142
00:07:18,980 --> 00:07:15,120
land ocean and atmosphere composition to

143
00:07:22,520 --> 00:07:18,990
earth and here we have the energy part

144
00:07:23,930 --> 00:07:22,530
that's this and a part of this where

145
00:07:29,170 --> 00:07:23,940
we're using the stellar flux and the

146
00:07:34,070 --> 00:07:29,180
surface of the planet and then for the

147
00:07:35,630 --> 00:07:34,080
amounts of solids and liquids and so on

148
00:07:39,530 --> 00:07:35,640
we're considering a thin surface layer

149
00:07:43,340 --> 00:07:39,540
okay and we need well the ocean the

150
00:07:47,030 --> 00:07:43,350
ocean fraction and we're assuming if we

151
00:07:49,940 --> 00:07:47,040
don't know how that planet is or where

152
00:07:52,070 --> 00:07:49,950
it is in time how it was at a certain

153
00:07:54,290 --> 00:07:52,080
point we're going to consider in this

154
00:07:56,810 --> 00:07:54,300
case that the atmospheres are the same

155
00:07:59,450 --> 00:07:56,820
so that will cancel in this in this

156
00:08:01,220 --> 00:07:59,460
equation and we just we only need the

157
00:08:03,800 --> 00:08:01,230
ocean fraction and to get the amount of

158
00:08:05,690 --> 00:08:03,810
ocean and the amount of land okay so

159
00:08:09,110 --> 00:08:05,700
this would be our mass energy

160
00:08:13,790 --> 00:08:09,120
availability index for planets our

161
00:08:17,450 --> 00:08:13,800
comparison is with earth okay so let's

162
00:08:22,460 --> 00:08:17,460
apply that applying that to early Mars

163
00:08:25,280 --> 00:08:22,470

with an ocean so earth is our point of

164
00:08:27,980 --> 00:08:25,290
reference so that earth then has a mass

165
00:08:31,420 --> 00:08:27,990
energy availability of one with a global

166
00:08:34,640 --> 00:08:31,430
NPP of 105 Giga tons of carbon per year

167
00:08:37,910 --> 00:08:34,650
now comparing that to early Mars with an

168
00:08:40,709 --> 00:08:37,920
ocean the mass-energy habitability of

169
00:08:42,990 --> 00:08:40,719
early Mars would be point zero two

170
00:08:46,050 --> 00:08:43,000
and that would correspond to a global

171
00:08:49,679 --> 00:08:46,060
MPG of 2.4 gig attends of carbon per

172
00:08:54,059 --> 00:08:49,689
year so there early Mars with an ocean

173
00:09:00,679 --> 00:08:54,069
was at least 40 times less habitable

174
00:09:03,480 --> 00:09:00,689
than Earth today okay so in conclusion

175
00:09:05,160 --> 00:09:03,490
habitability metrics allow us to

176
00:09:07,860 --> 00:09:05,170
identify and prioritize targets of

177
00:09:10,350 --> 00:09:07,870
interests simplify our understanding of

178
00:09:12,150 --> 00:09:10,360
habitable environments and compare

179
00:09:14,340 --> 00:09:12,160
results from simulations for examples

180
00:09:17,309 --> 00:09:14,350
when people are creating climate models

181
00:09:20,610 --> 00:09:17,319
for exoplanets you could use that for

182
00:09:22,530 --> 00:09:20,620
that the mass-energy have a living

183
00:09:23,999 --> 00:09:22,540
metric was constructed to characterize

184
00:09:26,460 --> 00:09:24,009
the potential habitability of

185
00:09:29,040 --> 00:09:26,470
environments based on the maximum

186
00:09:33,749 --> 00:09:29,050
quantity of mass and energy available

187
00:09:36,389 --> 00:09:33,759
for life a different metric could also

188
00:09:39,809 --> 00:09:36,399

be constructed to evaluate the quality

189
00:09:42,780 --> 00:09:39,819
of the environment our mass energy

190
00:09:43,290 --> 00:09:42,790
hability was validated using terrestrial

191
00:09:46,829 --> 00:09:43,300
biomes

192
00:09:48,329 --> 00:09:46,839
and we see that the general trend is

193
00:09:50,850 --> 00:09:48,339
that the suitability of planets to

194
00:09:53,150 --> 00:09:50,860
sustain a larger biosphere increases

195
00:09:55,590 --> 00:09:53,160
with the fourth power of the radius

196
00:09:59,309 --> 00:09:55,600
given that all other conditions are

197
00:10:01,379 --> 00:09:59,319
similar to earth therefore biosphere on

198
00:10:03,960 --> 00:10:01,389
planets slightly larger than the earth

199
00:10:06,059 --> 00:10:03,970
for example super Earths might be more

200
00:10:07,530 --> 00:10:06,069
susceptible to atmospheric chemical

201
00:10:09,629 --> 00:10:07,540
disequilibrium in other words bio

202
00:10:16,510 --> 00:10:09,639
signatures and that will conclude the

203
00:10:21,590 --> 00:10:19,970
all right if you're able to get to the

204
00:10:23,840 --> 00:10:21,600
microphone to ask your question please

205
00:10:27,080 --> 00:10:23,850
do so otherwise this creature and then

206
00:10:33,320 --> 00:10:27,090
we'll try to spot you thank you for that

207
00:10:37,340 --> 00:10:33,330
talk so your model is based on that it

208
00:10:39,590 --> 00:10:37,350
has exactly the same atmosphere land

209
00:10:43,070 --> 00:10:39,600
ocean and so on as the earth in

210
00:10:44,630 --> 00:10:43,080
proportion where no no it doesn't have

211
00:10:48,380 --> 00:10:44,640
to have the same proportions it's just

212
00:10:51,290 --> 00:10:48,390
similar so that you have land you have a

213
00:10:54,530 --> 00:10:51,300

rocky planet it has some amount of water

214
00:10:58,640 --> 00:10:54,540
and it has some atmosphere but we would

215
00:11:01,630 --> 00:10:58,650
expect we would want the composition to

216
00:11:07,700 --> 00:11:01,640
be somewhat similar so what would the

217
00:11:10,700 --> 00:11:07,710
index be for Venus hmmm what we haven't

218
00:11:13,850 --> 00:11:10,710
made that calculation but given that it

219
00:11:16,340 --> 00:11:13,860
has very little water start with at that

220
00:11:18,560 --> 00:11:16,350
point but well that would you know

221
00:11:21,530 --> 00:11:18,570
basically give it a very very low value

222
00:11:24,500 --> 00:11:21,540
oh well that's with our knowledge that

223
00:11:26,570 --> 00:11:24,510
it has a high water but in the context

224
00:11:29,600 --> 00:11:26,580
of an exoplanet just using the rate okay

225
00:11:32,360 --> 00:11:29,610
in a context of an exoplanet we would

226
00:11:34,940 --> 00:11:32,370
basically need to model that exoplanet

227
00:11:36,950 --> 00:11:34,950
and the conditions for that exoplanet we

228
00:11:38,990 --> 00:11:36,960
wouldn't be able to evaluate and until

229
00:11:41,870 --> 00:11:39,000
we get more information and then we

230
00:11:43,550 --> 00:11:41,880
could apply that but basically in terms

231
00:11:45,710 --> 00:11:43,560
of emotional animations of Venus means

232
00:11:49,280 --> 00:11:45,720
measuring the surface temperature really

233
00:11:50,510 --> 00:11:49,290
um yes yes measuring the surface

234
00:11:53,390 --> 00:11:50,520
temperature mm-hmm

235
00:11:55,250 --> 00:11:53,400
if you can get like we at this point we

236
00:11:56,720 --> 00:11:55,260
can already start to identifying

237
00:11:59,420 --> 00:11:56,730
materials in the atmospheres of

238
00:12:01,190 --> 00:11:59,430

exoplanets and probably a little bit

239
00:12:04,370 --> 00:12:01,200
later on a few years later on we'll be

240
00:12:06,530 --> 00:12:04,380
able to measure other aspects of the

241
00:12:10,760 --> 00:12:06,540
exoplanet so that's when we would be

242
00:12:13,010 --> 00:12:10,770
able to get actual values that are you

243
00:12:16,040 --> 00:12:13,020
know more indicative of an actual

244
00:12:18,830 --> 00:12:16,050
exoplanet but in the meantime we could

245
00:12:20,930 --> 00:12:18,840
still model exoplanets and we this is

246
00:12:23,120 --> 00:12:20,940
still useful for that purpose to be able

247
00:12:24,460 --> 00:12:23,130
to compare exoplanets based on the

248
00:12:28,870 --> 00:12:24,470
models okay

249
00:12:33,100 --> 00:12:28,880
awesome hi this is Rene Heller my

250
00:12:35,260 --> 00:12:33,110
question is the biomass production rate

251
00:12:37,570 --> 00:12:35,270
if I remember correctly goes with as you

252
00:12:39,430 --> 00:12:37,580
say their radius of the pen to the

253
00:12:41,470 --> 00:12:39,440
fourth to the force okay first question

254
00:12:44,740 --> 00:12:41,480
would be where does the number four come

255
00:12:48,670 --> 00:12:44,750
from its second how I mean there is no

256
00:12:52,450 --> 00:12:48,680
cap obviously soy to PETA would have the

257
00:12:54,370 --> 00:12:52,460
largest biomass okay so two things first

258
00:12:55,420 --> 00:12:54,380
of all we're looking for we're working

259
00:12:59,380 --> 00:12:55,430
at this point we're working with

260
00:13:07,030 --> 00:12:59,390
earth-like planets so Jupiter is not

261
00:13:10,000 --> 00:13:07,040
Earth alike and okay so we what we would

262
00:13:13,510 --> 00:13:10,010
do is yeah we would compare earth

263
00:13:18,210 --> 00:13:13,520

super-earths smaller smaller planets

264
00:13:21,640 --> 00:13:18,220
that are similar but there's a limit to

265
00:13:23,320 --> 00:13:21,650
where the super Earths lie but I don't

266
00:13:25,810 --> 00:13:23,330
quite remember where it was

267
00:13:31,300 --> 00:13:25,820
there's a certain particular value where

268
00:13:37,420 --> 00:13:31,310
you start getting gas giants oh yeah the

269
00:13:38,190 --> 00:13:37,430
number four okay so you look at this

270
00:13:40,570 --> 00:13:38,200
over here

271
00:13:42,640 --> 00:13:40,580
part of this comes from the surface of

272
00:13:46,030 --> 00:13:42,650
the planet and part of this comes from

273
00:13:49,240 --> 00:13:46,040
the volume and this is because this this

274
00:13:51,220 --> 00:13:49,250
happens where we you know we have the

275
00:13:54,040 --> 00:13:51,230
stellar flux times the times of the area

276
00:13:59,860 --> 00:13:54,050
for the energy and then you would have

277
00:14:02,830 --> 00:13:59,870
another are from from the volume

278
00:14:04,990 --> 00:14:02,840
consideration so it's a little bit of

279
00:14:06,250 --> 00:14:05,000
volume and a little bit of surface and

280
00:14:10,810 --> 00:14:06,260
that's where you get the art of the

281
00:14:13,210 --> 00:14:10,820
fourth power here okay we can take one

282
00:14:15,520 --> 00:14:13,220
more question if it's a quick one so the

283
00:14:17,350 --> 00:14:15,530
claim would be the habitability space

284
00:14:19,960 --> 00:14:17,360
value is high the planet is more likely

285
00:14:22,300 --> 00:14:19,970
to be habitable this value is low that

286
00:14:24,220 --> 00:14:22,310
is the ultimate aim could you repeat

287
00:14:26,290 --> 00:14:24,230
that again so a high value of the index

288
00:14:29,290 --> 00:14:26,300

should mean more likely to be habitable

289
00:14:30,880 --> 00:14:29,300
it's a quantitative yeah yes yes but

290
00:14:32,829 --> 00:14:30,890
surely with a number of priorities

291
00:14:34,900 --> 00:14:32,839
you're missing out to magnetic fields

292
00:14:37,300 --> 00:14:34,910
presence of water rock type actually

293
00:14:38,130 --> 00:14:37,310
there is no quantitative scaling between

294
00:14:40,080 --> 00:14:38,140
the value of that in

295
00:14:42,330 --> 00:14:40,090
see and the chance that planet really

296
00:14:44,820 --> 00:14:42,340
been habitable in reality okay at this

297
00:14:47,280 --> 00:14:44,830
point what we're doing is we're we're

298
00:14:51,690 --> 00:14:47,290
basically putting an upper limit to the

299
00:14:54,990 --> 00:14:51,700
habitability and later on we can develop

300
00:14:56,580 --> 00:14:55,000
this model or other indices so that we

301
00:14:59,400 --> 00:14:56,590
can take those things into consideration

302
00:15:03,210 --> 00:14:59,410
how those factors would affect how much

303
00:15:07,770 --> 00:15:03,220
of the solid liquid and gas is really

304
00:15:09,510 --> 00:15:07,780
available for for for life so I think I

305
00:15:11,190 --> 00:15:09,520
would argue that such metrics are quite

306
00:15:12,720 --> 00:15:11,200
good for sample selection to try and

307
00:15:15,090 --> 00:15:12,730
look at the planets for more information

308
00:15:17,940 --> 00:15:15,100
but I think to say it is quantitatively

309
00:15:19,710 --> 00:15:17,950
response proportional to habitability is

310
00:15:21,960 --> 00:15:19,720
just wrong sorry we're just going to

311
00:15:23,520 --> 00:15:21,970
have to cut the questions there let's go