
AbSciCon
2017
MESA, ARIZONA

1
00:00:16,830 --> 00:00:12,250
[Music]

2
00:00:20,670 --> 00:00:16,840
thank you first I wanted to acknowledge

3
00:00:22,939 --> 00:00:20,680
my co-authors microwave David Amundsen

4
00:00:25,529 --> 00:00:22,949
who did a lot of work for this talk and

5
00:00:28,609 --> 00:00:25,539
I'm just the one up here delivering the

6
00:00:31,319 --> 00:00:28,619
talk and the background of this slide is

7
00:00:33,810 --> 00:00:31,329
what a climate modeler would like to

8
00:00:39,560 --> 00:00:33,820
believe that Proxima Centauri B would

9
00:00:44,940 --> 00:00:41,479
according to a number of people

10
00:00:46,950 --> 00:00:44,950
including people in this room Proxima

11
00:00:48,030 --> 00:00:46,960
Centauri B probably doesn't have an

12
00:00:51,510 --> 00:00:48,040
atmosphere if it has an atmosphere

13
00:00:52,500 --> 00:00:51,520

probably doesn't have water and I think

14
00:00:54,450 --> 00:00:52,510
we're going to hear another talk by

15
00:00:56,639 --> 00:00:54,460
rodrigo in a little while

16
00:00:59,370 --> 00:00:56,649
talking about the same type of thing and

17
00:01:03,210 --> 00:00:59,380
so but if you read these papers at least

18
00:01:05,340 --> 00:01:03,220
couple of them it may have water there

19
00:01:07,679 --> 00:01:05,350
are ways it could have formed farther

20
00:01:09,389 --> 00:01:07,689
out and migrated in it could have been

21
00:01:10,800 --> 00:01:09,399
formed with tons of water not lost all

22
00:01:13,380 --> 00:01:10,810
of it but formed by the hydrogen

23
00:01:16,109 --> 00:01:13,390
envelope and that burned off and left

24
00:01:19,410 --> 00:01:16,119
something reasonable behind so there are

25
00:01:21,870 --> 00:01:19,420
ways it could happen and so it's

26
00:01:23,459 --> 00:01:21,880
interesting actually as an experience to

27
00:01:24,989 --> 00:01:23,469
get up and give a talk about an

28
00:01:28,010 --> 00:01:24,999
atmosphere that may not actually exist

29
00:01:30,569 --> 00:01:28,020
but the purposes of the next 10 minutes

30
00:01:32,340 --> 00:01:30,579
let's be optimistic and imagine that it

31
00:01:34,459 --> 00:01:32,350
does exist and imagine what possible

32
00:01:38,910 --> 00:01:34,469
climates of such planet might look like

33
00:01:42,449 --> 00:01:38,920
and so climate models are optimistic in

34
00:01:44,550 --> 00:01:42,459
general there we have to be as I a model

35
00:01:46,319 --> 00:01:44,560
21st century earth climate change and if

36
00:01:49,999 --> 00:01:46,329
you if you're not an optimist about

37
00:01:52,919 --> 00:01:50,009
things it'll just drive you crazy so

38
00:01:55,169 --> 00:01:52,929

anyway other people have tried to model

39
00:01:56,849 --> 00:01:55,179
the climate of Proxima be assuming it

40
00:01:57,779 --> 00:01:56,859
has different kinds of atmospheres and

41
00:02:00,089 --> 00:01:57,789
you can change the kind of atmosphere

42
00:02:01,349 --> 00:02:00,099
and get more warming in less Grumio more

43
00:02:03,569 --> 00:02:01,359
greenhouse warming less greenhouse

44
00:02:05,609 --> 00:02:03,579
warming and so on people usually start

45
00:02:07,800 --> 00:02:05,619
with earth-like type atmospheres with

46
00:02:09,600 --> 00:02:07,810
about a bar of nitrogen with some modest

47
00:02:11,240 --> 00:02:09,610
amount of something like co2 and so on

48
00:02:14,339 --> 00:02:11,250
and so forth and here are two examples

49
00:02:16,890 --> 00:02:14,349
from the literature from much orbit at

50
00:02:19,020 --> 00:02:16,900
all use Neil and D model and from boodle

51
00:02:22,190 --> 00:02:19,030
at all using the British Met office

52
00:02:24,000 --> 00:02:22,200
model both of them making the same

53
00:02:26,429 --> 00:02:24,010
assumption

54
00:02:29,280 --> 00:02:26,439
with an aqua planet that is an ocean

55
00:02:31,979 --> 00:02:29,290
covered surface no exposed land and a

56
00:02:34,649 --> 00:02:31,989
static ocean of thermodynamics or slab

57
00:02:36,559 --> 00:02:34,659
ocean and so the ocean sits there it

58
00:02:40,050 --> 00:02:36,569
absorbs sunlight if it absorbs this

59
00:02:42,180 --> 00:02:40,060
starlight it it is liquid if it doesn't

60
00:02:44,190 --> 00:02:42,190
it turns into ice that evaporates water

61
00:02:47,910 --> 00:02:44,200
does things like that but it doesn't

62
00:02:50,580 --> 00:02:47,920
move around and so basically at the sub

63
00:02:53,610 --> 00:02:50,590

stellar point here you get liquid water

64
00:02:56,009 --> 00:02:53,620
and outside the zero degrees C Line you

65
00:02:59,069 --> 00:02:56,019
get ice alright and you can see similar

66
00:03:01,680 --> 00:02:59,079
results in both models and so for this

67
00:03:03,750 --> 00:03:01,690
type of planet what happens at the sub

68
00:03:06,180 --> 00:03:03,760
stellar point stays at the sub stellar

69
00:03:09,470 --> 00:03:06,190
point and rapier Homburg called that

70
00:03:13,020 --> 00:03:09,480
configuration eyeball earth alright and

71
00:03:15,539 --> 00:03:13,030
that's sort of the the the typical way

72
00:03:19,649 --> 00:03:15,549
that people who use 3d models try to

73
00:03:21,599 --> 00:03:19,659
simulate exoplanets because it's the

74
00:03:23,910 --> 00:03:21,609
quickest way of doing those calculations

75
00:03:26,670 --> 00:03:23,920
but oceans are a lot more interesting

76
00:03:29,039 --> 00:03:26,680
than that they do other things but

77
00:03:30,509 --> 00:03:29,049
actually matter to the climate so oceans

78
00:03:32,039 --> 00:03:30,519
have thermal inertia and depending on

79
00:03:33,270 --> 00:03:32,049
how deep you assume the ocean is it can

80
00:03:35,129 --> 00:03:33,280
have a lot of thermal inertia which

81
00:03:37,830 --> 00:03:35,139
really slows down the response of the

82
00:03:38,939 --> 00:03:37,840
climate to a change in installation

83
00:03:42,659 --> 00:03:38,949
alright

84
00:03:44,610 --> 00:03:42,669
oceans transport heat in GCMs without a

85
00:03:45,960 --> 00:03:44,620
dynamic ocean the atmosphere atmosphere

86
00:03:48,809 --> 00:03:45,970
transport seep of the ocean does not

87
00:03:51,330 --> 00:03:48,819
oceans transport heat and make it a lot

88
00:03:53,759 --> 00:03:51,340

easier to keep things warmer over a

89
00:03:55,530 --> 00:03:53,769
larger region of the atmosphere but they

90
00:03:57,509 --> 00:03:55,540
take heat away from the sub stellar

91
00:04:00,119 --> 00:03:57,519
region as we'll see in a minute and keep

92
00:04:01,619 --> 00:04:00,129
things cooler there and that was

93
00:04:04,379 --> 00:04:01,629
demonstrated in the paper by WHO and

94
00:04:07,229 --> 00:04:04,389
yang 2014 who uses dynamic ocean to

95
00:04:09,240 --> 00:04:07,239
simulate a generic planet orbiting an M

96
00:04:11,550 --> 00:04:09,250
star and then another point that hasn't

97
00:04:13,939 --> 00:04:11,560
been emphasized very much in this one

98
00:04:17,520 --> 00:04:13,949
paper by Colin at all is that oceans

99
00:04:19,770 --> 00:04:17,530
have salt in them and salinity depresses

100
00:04:21,270 --> 00:04:19,780
the freezing point that's a good thing

101
00:04:22,439 --> 00:04:21,280
if you're trying to make habitable

102
00:04:24,540 --> 00:04:22,449
planet people do a lot of

103
00:04:25,560 --> 00:04:24,550
experimentation with composition of the

104
00:04:28,080 --> 00:04:25,570
atmosphere they don't do much

105
00:04:30,330 --> 00:04:28,090
experimentation for composition of the

106
00:04:33,659 --> 00:04:30,340
ocean so let's look at a couple of those

107
00:04:36,149 --> 00:04:33,669
things so we're doing our simulations

108
00:04:37,559 --> 00:04:36,159
with a different 3d general circulation

109
00:04:39,899 --> 00:04:37,569
model called Rocky

110
00:04:41,730 --> 00:04:39,909
Reidy that's developed at NASA Goddard

111
00:04:43,409 --> 00:04:41,740
Institute for Space Studies as an

112
00:04:46,889 --> 00:04:43,419
outgrowth of our terrestrial climate

113
00:04:49,589 --> 00:04:46,899

model and that model is described in a

114
00:04:53,219 --> 00:04:49,599
paper oops so I'm going away how do I go

115
00:04:54,989 --> 00:04:53,229
back let's see there we go it's

116
00:04:57,629 --> 00:04:54,999
described in a paper by microwave all

117
00:04:59,519 --> 00:04:57,639
that's been posted on the archive and

118
00:05:02,879 --> 00:04:59,529
it's under review and app.js supplement

119
00:05:04,889 --> 00:05:02,889
series it's four by five degree model

120
00:05:07,859 --> 00:05:04,899
with 40 layers in the atmospheres we're

121
00:05:09,899 --> 00:05:07,869
using a 900 meter deep ocean with nine

122
00:05:11,339 --> 00:05:09,909
layers assuming an actual planet like

123
00:05:13,409 --> 00:05:11,349
the previous studies we're doing runs

124
00:05:15,089 --> 00:05:13,419
with synchronous rotation but we're also

125
00:05:16,969 --> 00:05:15,099
doing runs with three two spin orbit

126
00:05:19,309 --> 00:05:16,979
orbit resonance one with zero

127
00:05:21,869 --> 00:05:19,319
eccentricity and learn with 0.3

128
00:05:23,219 --> 00:05:21,879
eccentricity which is close to the upper

129
00:05:26,309 --> 00:05:23,229
limit that people think is reasonable

130
00:05:28,709 --> 00:05:26,319
we're using sort of typical fo earth

131
00:05:29,939 --> 00:05:28,719
type atmosphere for today's top but

132
00:05:31,769 --> 00:05:29,949
we're trying other compositions and

133
00:05:33,359 --> 00:05:31,779
we're using an ocean with different

134
00:05:35,609 --> 00:05:33,369
salinities something typical of the

135
00:05:37,939 --> 00:05:35,619
earth something that's fresh water and

136
00:05:41,579 --> 00:05:37,949
something that's more like the Dead Sea

137
00:05:44,070 --> 00:05:41,589
and so here are examples of what you get

138
00:05:46,049 --> 00:05:44,080

with such a model on the left just as a

139
00:05:48,290 --> 00:05:46,059
sanity check we ran our model first with

140
00:05:50,850 --> 00:05:48,300
a thermodynamic ocean that the previous

141
00:05:52,320 --> 00:05:50,860
modeling papers use just to show you

142
00:05:55,139 --> 00:05:52,330
that we can get the same result for that

143
00:05:58,499 --> 00:05:55,149
type of simulation I bowler but now here

144
00:06:00,149 --> 00:05:58,509
is the result for the ocean the dynamic

145
00:06:02,459 --> 00:06:00,159
ocean and it looks very much actually

146
00:06:05,790 --> 00:06:02,469
like what whoo and Yanks on their 2014

147
00:06:07,230 --> 00:06:05,800
paper what happens that in response to

148
00:06:10,469 --> 00:06:07,240
the heating at the sub stellar point

149
00:06:13,129 --> 00:06:10,479
over here you get these atmospheric

150
00:06:16,739 --> 00:06:13,139
waves Rossby waves on either side of the

151
00:06:18,389 --> 00:06:16,749
of the equator upstream of the sub

152
00:06:20,489 --> 00:06:18,399
stellar point and then you get a Kelvin

153
00:06:23,489 --> 00:06:20,499
way downstream creates this unusual

154
00:06:25,739 --> 00:06:23,499
pattern of above freezing temperatures

155
00:06:27,719 --> 00:06:25,749
and I should but say by the way that I'm

156
00:06:29,670 --> 00:06:27,729
using a color bar convention in which

157
00:06:31,709 --> 00:06:29,680
the transition from blue to yellow is

158
00:06:34,949 --> 00:06:31,719
the transition from below to above

159
00:06:36,649 --> 00:06:34,959
freezing not below to above zero degrees

160
00:06:38,999 --> 00:06:36,659
C because it's different with salt so

161
00:06:41,219 --> 00:06:39,009
anything this yellow is is liquid water

162
00:06:44,069 --> 00:06:41,229
and this was called Baku and yang

163
00:06:47,610 --> 00:06:44,079

Lobster Earth instead of eyeball earth

164
00:06:49,870 --> 00:06:47,620
and you go from a planet that has only

165
00:06:51,700 --> 00:06:49,880
20% open ocean without the dynamic ocean

166
00:06:54,760 --> 00:06:51,710
into something has open more than twice

167
00:06:56,440 --> 00:06:54,770
the open ocean even though the maximum

168
00:06:58,720 --> 00:06:56,450
temperature the substellar point is a

169
00:07:02,020 --> 00:06:58,730
lot cooler than it is with the

170
00:07:04,240 --> 00:07:02,030
thermodynamic ocean still this barely

171
00:07:06,490 --> 00:07:04,250
above freezing seemingly water is

172
00:07:09,700 --> 00:07:06,500
covering a fairly large fraction in the

173
00:07:11,740 --> 00:07:09,710
planet okay something else people worry

174
00:07:13,480 --> 00:07:11,750
about for habitability is the transition

175
00:07:15,970 --> 00:07:13,490
to a moist greenhouse especially around

176
00:07:17,680 --> 00:07:15,980
m-step planets around M stars where

177
00:07:19,960 --> 00:07:17,690
there's lots of shortwave absorption by

178
00:07:21,070 --> 00:07:19,970
water vapor that can wind up putting

179
00:07:23,650 --> 00:07:21,080
lots of water vapor into the

180
00:07:26,050 --> 00:07:23,660
stratosphere and get you to an on

181
00:07:28,150 --> 00:07:26,060
habitable climate sooner than you like

182
00:07:30,580 --> 00:07:28,160
and that's a concern for n star M stars

183
00:07:33,880 --> 00:07:30,590
this is a figure from a paper that we

184
00:07:35,920 --> 00:07:33,890
have in review by Yuka Fuji in app j

185
00:07:39,010 --> 00:07:35,930
showing how the stratosphere water vapor

186
00:07:41,560 --> 00:07:39,020
changes with total incident flux for

187
00:07:43,210 --> 00:07:41,570
four different kinds of stars here this

188
00:07:45,040 --> 00:07:43,220

is the same thing plotted versus surface

189
00:07:46,510 --> 00:07:45,050
temperature substellar point and this is

190
00:07:47,890 --> 00:07:46,520
the same thing plotted versus the near

191
00:07:50,080 --> 00:07:47,900
IR flux which is actually the

192
00:07:50,710 --> 00:07:50,090
fundamental parameter for stratospheric

193
00:07:53,110 --> 00:07:50,720
water vapor

194
00:07:54,810 --> 00:07:53,120
just to show you Proxima B just gets too

195
00:07:57,760 --> 00:07:54,820
little installation it's nowhere near

196
00:07:59,110 --> 00:07:57,770
this place up here where you start to

197
00:08:02,080 --> 00:07:59,120
worry about moist greenhouses so

198
00:08:04,990 --> 00:08:02,090
whatever else may be bad about Proxima

199
00:08:06,640 --> 00:08:05,000
be moist greenhouse is not one of them

200
00:08:10,900 --> 00:08:06,650
given how little installation it

201
00:08:12,940 --> 00:08:10,910
receives okay onto more exotic types of

202
00:08:14,710 --> 00:08:12,950
oceans on the Left we've shown the

203
00:08:17,620 --> 00:08:14,720
result with the experiment which we've

204
00:08:20,950 --> 00:08:17,630
used a fresh water ocean zero salinity

205
00:08:23,170 --> 00:08:20,960
and on the right we've used this dead

206
00:08:25,780 --> 00:08:23,180
sea salinity of two hundred and sixty

207
00:08:28,300 --> 00:08:25,790
practical salinity units that's grams

208
00:08:30,490 --> 00:08:28,310
per kilogram well talk about the

209
00:08:33,100 --> 00:08:30,500
freshwater case first you can see

210
00:08:34,870 --> 00:08:33,110
compared to the nominal Lobster earth

211
00:08:36,370 --> 00:08:34,880
pattern the pattern is still there but

212
00:08:40,390 --> 00:08:36,380
it's a lot smaller this is kind of a

213
00:08:41,890 --> 00:08:40,400

baby lobster the reason the reason is

214
00:08:43,630 --> 00:08:41,900
that in the ocean you have two different

215
00:08:46,240 --> 00:08:43,640
kinds of heat transport you have a

216
00:08:47,650 --> 00:08:46,250
wind-driven heat transport that's

217
00:08:49,530 --> 00:08:47,660
usually in the upper layers and then you

218
00:08:51,790 --> 00:08:49,540
have a density driven or thermohaline

219
00:08:53,620 --> 00:08:51,800
circulation in which the density

220
00:08:55,480 --> 00:08:53,630
differences that drive it are due to

221
00:08:57,820 --> 00:08:55,490
temperature differences and salinity

222
00:08:59,710 --> 00:08:57,830
differences you take away the salt and

223
00:09:01,750 --> 00:08:59,720
you only have the temperature component

224
00:09:03,300 --> 00:09:01,760
so you weaken thermohaline circulation

225
00:09:04,949 --> 00:09:03,310
you can't transport as

226
00:09:07,110 --> 00:09:04,959
and then there's the peculiar feature of

227
00:09:09,780 --> 00:09:07,120
fresh water that its density peaks at

228
00:09:11,610 --> 00:09:09,790
four degrees C which is not the case for

229
00:09:13,439 --> 00:09:11,620
salty water and so as you move away from

230
00:09:15,059 --> 00:09:13,449
the substellar point and move towards

231
00:09:16,860 --> 00:09:15,069
zero you actually get to this four

232
00:09:18,509 --> 00:09:16,870
degrees C contour and all the water

233
00:09:20,040 --> 00:09:18,519
starts to sink around the edges there

234
00:09:22,139 --> 00:09:20,050
and it's not available actually to

235
00:09:23,939 --> 00:09:22,149
transport the near near surface water

236
00:09:27,420 --> 00:09:23,949
around to the Nightside so you get a

237
00:09:29,600 --> 00:09:27,430
very confined region of of open oceans

238
00:09:32,579 --> 00:09:29,610

only 32% but you go to very high

239
00:09:34,290 --> 00:09:32,589
salinity and pun intended

240
00:09:36,689 --> 00:09:34,300
take the simulation with a grain of salt

241
00:09:40,350 --> 00:09:36,699
these this ocean model was not intended

242
00:09:42,030 --> 00:09:40,360
to go up to things like 260 PSU but the

243
00:09:43,889 --> 00:09:42,040
one thing that you probably can't count

244
00:09:47,309 --> 00:09:43,899
on is that the freezing point is very

245
00:09:49,410 --> 00:09:47,319
very depressed at 260 PSU it's down

246
00:09:51,739 --> 00:09:49,420
there minded but it's about it and at

247
00:09:54,360 --> 00:09:51,749
the eutectic point it's about

248
00:09:56,040 --> 00:09:54,370
closed-toed minus 21 degrees or

249
00:09:58,799 --> 00:09:56,050
something like that and so you wind up

250
00:10:03,210 --> 00:09:58,809
having a planet that is not above 0

251
00:10:05,790 --> 00:10:03,220
degrees C anywhere on the planet yet 97%

252
00:10:07,499 --> 00:10:05,800
of the planet is liquid water ok and so

253
00:10:09,900 --> 00:10:07,509
you don't have to build up bars of co2

254
00:10:11,460 --> 00:10:09,910
to make a planet that is technically

255
00:10:13,290 --> 00:10:11,470
habitable in its ability to sustain

256
00:10:15,629 --> 00:10:13,300
surface liquid water you can make

257
00:10:18,360 --> 00:10:15,639
something that looks completely cold but

258
00:10:21,749 --> 00:10:18,370
still could be habitable with the price

259
00:10:23,900 --> 00:10:21,759
you pay that it's really really salty ok

260
00:10:26,549 --> 00:10:23,910
is a really really salty ocean

261
00:10:28,259 --> 00:10:26,559
conceivable well maybe I don't really

262
00:10:30,299 --> 00:10:28,269
actually know that much about that but

263
00:10:32,549 --> 00:10:30,309

people who study Europa there's a paper

264
00:10:35,309 --> 00:10:32,559
from Han and Chava where these Galileo

265
00:10:38,429 --> 00:10:35,319
magnetometer data to try to figure out

266
00:10:39,929 --> 00:10:38,439
how saline Europa's subsurface ocean may

267
00:10:41,340 --> 00:10:39,939
be and in the end they kind of came to

268
00:10:44,100 --> 00:10:41,350
the conclusion by the way Europa they

269
00:10:45,660 --> 00:10:44,110
think is not sodium chloride dominated

270
00:10:48,929 --> 00:10:45,670
ocean they think it's a magnesium

271
00:10:50,249 --> 00:10:48,939
sulfate epsom salts dominated ocean but

272
00:10:51,900 --> 00:10:50,259
they came to the conclusion that the

273
00:10:54,540 --> 00:10:51,910
Galileo magnetometer results are

274
00:10:56,100 --> 00:10:54,550
actually most consistent with a salinity

275
00:10:59,249 --> 00:10:56,110
of that ocean that's very close to

276
00:11:01,650 --> 00:10:59,259
saturation for magnesium sulfate and so

277
00:11:03,210 --> 00:11:01,660
the idea of a really really salty ocean

278
00:11:05,119 --> 00:11:03,220
we may actually even have an example

279
00:11:07,860 --> 00:11:05,129
right in our own solar system who knows

280
00:11:10,860 --> 00:11:07,870
could anything live in an ocean that

281
00:11:13,889 --> 00:11:10,870
salty and that cold well it's amazing

282
00:11:16,590 --> 00:11:13,899
the paper by McKittrick at all 2012 and

283
00:11:20,490 --> 00:11:16,600
they found this hello file

284
00:11:23,490 --> 00:11:20,500
planta caucus hello cryo Phyllis or 1 in

285
00:11:25,410 --> 00:11:23,500
Arctic permafrost and they run it back

286
00:11:29,100 --> 00:11:25,420
to the lab and got it to grow and divide

287
00:11:31,439 --> 00:11:29,110
at minus 15 degrees C at 180 practical

288
00:11:34,290 --> 00:11:31,449

salinity units so you know not bad Vic

289
00:11:37,379 --> 00:11:34,300
yeah life will find a way it's amazing

290
00:11:41,490 --> 00:11:37,389
right so the other thing that we did is

291
00:11:43,499 --> 00:11:41,500
to try to simulate Proxima Centauri B

292
00:11:46,139 --> 00:11:43,509
now not in synchronous rotation but in

293
00:11:48,059 --> 00:11:46,149
three two spin orbit resonance you get a

294
00:11:49,170 --> 00:11:48,069
very different situation depending on

295
00:11:51,210 --> 00:11:49,180
whether you assume there's any

296
00:11:52,920 --> 00:11:51,220
eccentricity or not without any

297
00:11:55,170 --> 00:11:52,930
eccentricity this is the pattern of

298
00:11:58,439 --> 00:11:55,180
incident stellar radiation without any

299
00:12:01,079 --> 00:11:58,449
eccentricity then you get an even a

300
00:12:02,639 --> 00:12:01,089
climatologically even there's a diurnal

301
00:12:04,379 --> 00:12:02,649
cycle of course because it's not in

302
00:12:06,230 --> 00:12:04,389
synchronous rotation but you get a

303
00:12:09,329 --> 00:12:06,240
climatologically even pattern of

304
00:12:11,910 --> 00:12:09,339
installation at all longitudes but if

305
00:12:15,120 --> 00:12:11,920
you add eccentricity this is the point

306
00:12:17,009 --> 00:12:15,130
three case then you don't because then

307
00:12:18,329 --> 00:12:17,019
basically every time you come around

308
00:12:21,540 --> 00:12:18,339
again

309
00:12:24,030 --> 00:12:21,550
a different side of the planet is

310
00:12:26,850 --> 00:12:24,040
spacing the star and so you get two

311
00:12:29,460 --> 00:12:26,860
preferred longitudes of high

312
00:12:31,740 --> 00:12:29,470
installation with weaker installation

313
00:12:33,240 --> 00:12:31,750

between so if you do if you apply this

314
00:12:35,069 --> 00:12:33,250
type of installation pattern to a

315
00:12:37,050 --> 00:12:35,079
thermodynamic ocean like the ones I

316
00:12:39,720 --> 00:12:37,060
showed you earlier then you don't get an

317
00:12:41,699 --> 00:12:39,730
eyeball or if you get a to eyeball earth

318
00:12:44,550 --> 00:12:41,709
is basically what you get with ice in

319
00:12:45,960 --> 00:12:44,560
between this is the sea ice cover that

320
00:12:49,110 --> 00:12:45,970
we get from the model with a dynamic

321
00:12:51,030 --> 00:12:49,120
ocean with this version of the

322
00:12:53,639 --> 00:12:51,040
installation there's just not there's

323
00:12:55,410 --> 00:12:53,649
you melt the planet on the day side in

324
00:12:57,629 --> 00:12:55,420
the equatorial region but it freezes up

325
00:13:00,120 --> 00:12:57,639
again on the night side so you get kind

326
00:13:02,280 --> 00:13:00,130
of climatologically partial sea ice

327
00:13:04,379 --> 00:13:02,290
cover in a small band near the equator

328
00:13:06,660 --> 00:13:04,389
and ice everyplace else no place that's

329
00:13:07,800 --> 00:13:06,670
completely ice-free but with this

330
00:13:11,819 --> 00:13:07,810
pattern where you're actually getting

331
00:13:14,819 --> 00:13:11,829
fairly intense installation in two

332
00:13:16,590 --> 00:13:14,829
places on the globe then you get open

333
00:13:17,970 --> 00:13:16,600
ocean and because the ocean transports

334
00:13:19,800 --> 00:13:17,980
heat because the ocean has a lot of

335
00:13:21,960 --> 00:13:19,810
thermal inertia so that it doesn't

336
00:13:23,460 --> 00:13:21,970
automatically freeze over once the

337
00:13:25,230 --> 00:13:23,470
planet moves over onto the night side

338
00:13:27,090 --> 00:13:25,240

you actually get a permanent

339
00:13:29,640 --> 00:13:27,100
what would people people would call a

340
00:13:32,220 --> 00:13:29,650
water belt of liquid water all around

341
00:13:33,660 --> 00:13:32,230
the planet so that's a fairly habitable

342
00:13:38,870 --> 00:13:33,670
looking planet and that's what normal

343
00:13:42,150 --> 00:13:38,880
earth type salinity okay so to conclude

344
00:13:45,030 --> 00:13:42,160
dynamic ocean implies that you might

345
00:13:48,180 --> 00:13:45,040
have a much colder but a broader

346
00:13:50,880 --> 00:13:48,190
habitable region then a static ocean

347
00:13:52,530 --> 00:13:50,890
would imply if you have a synchronously

348
00:13:55,320 --> 00:13:52,540
rotating planet with an earth-like

349
00:13:57,750 --> 00:13:55,330
atmosphere if you have a highly saline

350
00:14:00,630 --> 00:13:57,760
ocean you have this possibility of an

351
00:14:04,980 --> 00:14:00,640
almost completely liquid covered planet

352
00:14:07,340 --> 00:14:04,990
that nonetheless stays below zero

353
00:14:10,020 --> 00:14:07,350
degrees C everywhere on the planet and

354
00:14:11,940 --> 00:14:10,030
we have examples on earth of critters

355
00:14:14,400 --> 00:14:11,950
that actually grow in conditions like

356
00:14:16,380 --> 00:14:14,410
that amazingly if you have a planet in

357
00:14:18,030 --> 00:14:16,390
three to spin-orbit residence then with

358
00:14:20,610 --> 00:14:18,040
eccentricity you can produce a nice

359
00:14:23,250 --> 00:14:20,620
habitable belt of water around the

360
00:14:25,800 --> 00:14:23,260
equator and of course all of this is on

361
00:14:28,080 --> 00:14:25,810
the condition that Proxima B has an

362
00:14:31,140 --> 00:14:28,090
atmosphere and then it has water which

363
00:14:32,610 --> 00:14:31,150

it probably doesn't but maybe let's be

364
00:14:38,950 --> 00:14:32,620
optimistic thank

365
00:14:41,480 --> 00:14:38,960
[Applause]

366
00:14:42,920 --> 00:14:41,490
all right so we're about three minutes

367
00:14:49,730 --> 00:14:42,930
ahead of schedule so we have time for

368
00:14:51,650 --> 00:14:49,740
maybe a few quick questions so this is

369
00:14:53,900 --> 00:14:51,660
with an earth-like atmosphere but what

370
00:14:56,420 --> 00:14:53,910
happens if you increase the co2 maybe

371
00:15:01,160 --> 00:14:56,430
four five times or even more than that

372
00:15:04,040 --> 00:15:01,170
so so we're doing runs right now with an

373
00:15:06,200 --> 00:15:04,050
hour key and earth type atmosphere we're

374
00:15:09,110 --> 00:15:06,210
specifically doing runs with non

375
00:15:11,270 --> 00:15:09,120
atmosphere like what char net all looked

376
00:15:13,310 --> 00:15:11,280
at in their 2013 paper their case a

377
00:15:16,130 --> 00:15:13,320
which as I guess about point nine

378
00:15:20,620 --> 00:15:16,140
millibars of co2 point nine millibars of

379
00:15:23,750 --> 00:15:20,630
methane as well and you get a broader

380
00:15:26,360 --> 00:15:23,760
region of open ocean water but not a

381
00:15:27,650 --> 00:15:26,370
completely open ocean region for that if

382
00:15:29,510 --> 00:15:27,660
you go up to very high co2

383
00:15:31,850 --> 00:15:29,520
concentrations we have not done that

384
00:15:34,580 --> 00:15:31,860
experiment yet but tibetan all did that

385
00:15:37,040 --> 00:15:34,590
experiment with a one-bar co2 atmosphere

386
00:15:41,740 --> 00:15:37,050
for one-bar co2 atmosphere you can make

387
00:15:45,230 --> 00:15:43,730
another question about parameter

388
00:15:46,880 --> 00:15:45,240

sensitivity what happens if you change

389
00:15:50,150 --> 00:15:46,890
the rotation rate does the mat-su know

390
00:15:52,730 --> 00:15:50,160
gill pattern changes well or so so yeah

391
00:15:55,460 --> 00:15:52,740
so it the the details of it will change

392
00:15:59,060 --> 00:15:55,470
you'll still get the same basic pattern

393
00:16:01,220 --> 00:15:59,070
and I can tell you that for a fact that

394
00:16:02,450 --> 00:16:01,230
it changes the shape a little bit of the

395
00:16:03,770 --> 00:16:02,460
pattern but doesn't change the pattern

396
00:16:05,780 --> 00:16:03,780
because the first time we ran these

397
00:16:06,980 --> 00:16:05,790
experiments we mistakenly having the

398
00:16:09,260 --> 00:16:06,990
mistake in the code that gave us a

399
00:16:12,170 --> 00:16:09,270
rotation rate that was that was twice as

400
00:16:13,880 --> 00:16:12,180
slow as the actual rotation rate so

401
00:16:15,410 --> 00:16:13,890
changes the look of the pattern a little

402
00:16:18,500 --> 00:16:15,420
bit but the mat-su Nabeel pattern is

403
00:16:21,830 --> 00:16:18,510
still there all right make your last

404
00:16:23,270 --> 00:16:21,840
question quick okay I'll hold off on

405
00:16:25,250 --> 00:16:23,280
some of the comments that I had just a

406
00:16:27,560 --> 00:16:25,260
quick couple comments about two oceans

407
00:16:29,330 --> 00:16:27,570
in our own solar system i Jerry's still

408
00:16:32,030 --> 00:16:29,340
out about whether your opposition's

409
00:16:33,560 --> 00:16:32,040
magazine sulfate or sodium chloride in

410
00:16:35,030 --> 00:16:33,570
hand provided a lower bound the other

411
00:16:36,650 --> 00:16:35,040
thing is that if you're looking for a

412
00:16:39,740 --> 00:16:36,660
saturated ocean Callisto might be a good