AbSciCon 2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:11,459 --> 00:00:09,289
[Applause]

3
00:00:14,250 --> 00:00:11,469
morning everybody my name is Illya

4
00:00:15,990 --> 00:00:14,260
Wofford I am a postback at NASA Goddard

5
00:00:18,300 --> 00:00:16,000
Space Flight Center I'm really excited

6
00:00:19,800 --> 00:00:18,310
to be here so today I'm going to be

7
00:00:22,470 --> 00:00:19,810
talking to you about revisiting early

8
00:00:24,269 --> 00:00:22,480
Earth's methanogenic biosphere so if you

9
00:00:25,800 --> 00:00:24,279
were to think about early Earth you

10
00:00:27,689 --> 00:00:25,810
could think of it as like an exoplanet

11
00:00:31,710 --> 00:00:27,699
or a laboratory in which you can explore

12
00:00:35,790 --> 00:00:31,720
possible ranges of biospheres in which

13
00:00:37,110 --> 00:00:35,800

we can see what with the atmospheric

14
00:00:39,479 --> 00:00:37,120
composition of these terrestrial plants

15
00:00:40,709 --> 00:00:39,489
would look like and when we we also look

16
00:00:42,959 --> 00:00:40,719
about looking at when we think about

17
00:00:44,970 --> 00:00:42,969
early Earth is methane so you think

18
00:00:46,740 --> 00:00:44,980
about methane you think about

19
00:00:48,599 --> 00:00:46,750
methanogenesis which is one way we can

20
00:00:50,729 --> 00:00:48,609
create methane which in this case you

21
00:00:52,619 --> 00:00:50,739
have microbes that will take in these

22
00:00:54,209 --> 00:00:52,629
hydrogen molecules they will synthesize

23
00:00:56,069 --> 00:00:54,219
this methane in their bodies and

24
00:00:57,270 --> 00:00:56,079
eventually they will release it back

25
00:00:59,549 --> 00:00:57,280
into the oceans and they will eventually

26
00:01:01,200 --> 00:00:59,559
make its way into those atmospheres this

27
00:01:03,360 --> 00:01:01,210
is called biological methane production

28
00:01:05,130 --> 00:01:03,370
and we can use that biological methane

29
00:01:09,210 --> 00:01:05,140
production to create to look at

30
00:01:11,130 --> 00:01:09,220
biosignatures another way that we can

31
00:01:13,380 --> 00:01:11,140
see methane is that we can use

32
00:01:15,270 --> 00:01:13,390
serpentinization or abiotic methane

33
00:01:17,670 --> 00:01:15,280
productions which in this case motion

34
00:01:20,550 --> 00:01:17,680
across minerals such as such as olivine

35
00:01:22,380 --> 00:01:20,560
and pyroxene are will react with water

36
00:01:24,240 --> 00:01:22,390
and in that case you will create

37
00:01:26,010 --> 00:01:24,250
serpentine and as a byproduct of this

38
00:01:28,230 --> 00:01:26,020

reaction you will get hydrogen methane

39
00:01:39,480 --> 00:01:28,240
and heat that makes it a low temperature

40
00:01:41,399 --> 00:01:39,490
low pressure exothermic reaction so the

41
00:01:43,289 --> 00:01:41,409
motivation for our work is that we use

42
00:01:45,929 --> 00:01:43,299
dr. Chris Hansen Thailand's most recent

43
00:01:47,819 --> 00:01:45,939
project and what he did is he utilized

44
00:01:49,440 --> 00:01:47,829
the model to calculate methane fluxes

45
00:01:52,529 --> 00:01:49,450
based on oceanic parameters such as

46
00:01:54,660 --> 00:01:52,539
ocean crust arrest ocean crust ratios as

47
00:01:56,399 --> 00:01:54,670
well as seafloor spreading to name a few

48
00:01:58,289 --> 00:01:56,409
and was able to calculate a probability

49
00:01:59,999 --> 00:01:58,299
density of fluxes that could be

50
00:02:02,880 --> 00:02:00,009
explained by a by the methane production

51
00:02:04,410 --> 00:02:02,890
which is highlighted here so as you can

52
00:02:06,779 --> 00:02:04,420
see as you're moving the methane flex

53
00:02:08,070 --> 00:02:06,789
fluxes towards the 10 tera moles per

54
00:02:10,200 --> 00:02:08,080
year mark you can see that your

55
00:02:11,220 --> 00:02:10,210
probability is starting to go down but

56
00:02:12,600 --> 00:02:11,230
before that you can see that your

57
00:02:14,400 --> 00:02:12,610
probability density for a budding

58
00:02:16,050 --> 00:02:14,410
methane is pretty high so you could

59
00:02:18,119 --> 00:02:16,060
think of this as your abiotic methane

60
00:02:19,770 --> 00:02:18,129
range and then of course when you get to

61
00:02:21,210 --> 00:02:19,780
10 tera moles per year to approximately

62
00:02:23,040 --> 00:02:21,220
15 tera moles per year you can

63
00:02:24,990 --> 00:02:23,050

see that you're you there's still a

64
00:02:27,840 --> 00:02:25,000
slight chance it's very small less than

65
00:02:29,880 --> 00:02:27,850
0.1% of it to actually be justified by a

66
00:02:31,320 --> 00:02:29,890
body methane production so this you

67
00:02:33,180 --> 00:02:31,330
could think of as your gray area or your

68
00:02:35,940 --> 00:02:33,190
plausible methane biology biological

69
00:02:37,920 --> 00:02:35,950
methane production range and then of

70
00:02:39,480 --> 00:02:37,930
course after the 15 tera moles per year

71
00:02:42,060 --> 00:02:39,490
mark this is what you would consider

72
00:02:43,620 --> 00:02:42,070
your definitive biological methane

73
00:02:49,260 --> 00:02:43,630
production range in which where you

74
00:02:52,050 --> 00:02:49,270
would most likely see life so as we move

75
00:02:53,699 --> 00:02:52,060
focus me as I move forward into flagship

76
00:02:55,800 --> 00:02:53,709
missions such as Lavar we're going to

77
00:02:57,390 --> 00:02:55,810
rely on them to actually give us give us

78
00:03:00,750 --> 00:02:57,400
information how to identify spectral

79
00:03:01,920 --> 00:03:00,760
features of exoplanets particularly if

80
00:03:04,350 --> 00:03:01,930
we could actually see these spectral

81
00:03:07,860 --> 00:03:04,360
differences in biotic atmospheres versus

82
00:03:09,449 --> 00:03:07,870
anybody methane being produced so in our

83
00:03:10,830 --> 00:03:09,459
project what we did is use this model

84
00:03:12,990 --> 00:03:10,840
called Atomos which is a 1d

85
00:03:16,020 --> 00:03:13,000
photochemical climate model it consists

86
00:03:17,790 --> 00:03:16,030
of two two components you have the

87
00:03:19,710 --> 00:03:17,800
photochemical component which simulates

88
00:03:22,350 --> 00:03:19,720

atmospheric reactions in our case we're

89
00:03:24,060 --> 00:03:22,360
using arc and earth and then we take

90
00:03:25,500 --> 00:03:24,070
those reaction in atmospheric reactions

91
00:03:26,910 --> 00:03:25,510
and they're sent to a climate to the

92
00:03:28,620 --> 00:03:26,920
climate component which basically

93
00:03:30,270 --> 00:03:28,630
generates a temperature profile based on

94
00:03:31,920 --> 00:03:30,280
those photochemical reactions and this

95
00:03:33,509 --> 00:03:31,930
is an actual run that's being shown in

96
00:03:37,110 --> 00:03:33,519
real time even though the resolution is

97
00:03:38,970 --> 00:03:37,120
not very good another thing that we use

98
00:03:40,350 --> 00:03:38,980
is PSG or the planetary spectrum

99
00:03:42,690 --> 00:03:40,360
generator which basically takes those

100
00:03:44,699 --> 00:03:42,700
methane fluxes and we put them into this

101
00:03:45,690 --> 00:03:44,709
PSG over the spectrum generator in order

102
00:03:48,270 --> 00:03:45,700
to give us a spectra of what these

103
00:03:50,460 --> 00:03:48,280
fluxes would look like and then lastly

104
00:03:52,320 --> 00:03:50,470
we use lavars cronograph noise model

105
00:03:54,180 --> 00:03:52,330
which in this case what we did is that

106
00:03:55,680 --> 00:03:54,190
it was able to take those methane fluxes

107
00:03:59,220 --> 00:03:55,690
and essentially show us what the

108
00:04:00,660 --> 00:03:59,230
observers perspective would look like so

109
00:04:02,759 --> 00:04:00,670
in working order what we've done is

110
00:04:04,680 --> 00:04:02,769
we've given it a flux we gave it to at

111
00:04:06,630 --> 00:04:04,690
most at most then printed a mixing ratio

112
00:04:08,670 --> 00:04:06,640
we then plotted our flux versus mixing

113
00:04:11,250 --> 00:04:08,680

ratio and then we were able to give it

114
00:04:13,410 --> 00:04:11,260
to PSG which gave us the spectra which

115
00:04:14,580 --> 00:04:13,420
is here and then from those fluxes we

116
00:04:16,170 --> 00:04:14,590
able we were able to give it to the

117
00:04:17,670 --> 00:04:16,180
coronagraph to give us direct imaging of

118
00:04:23,250 --> 00:04:17,680
what the actual observer would actually

119
00:04:24,840 --> 00:04:23,260
see based on those fluxes so the bigger

120
00:04:26,610 --> 00:04:24,850
question is how will be spectral

121
00:04:28,890 --> 00:04:26,620
peeresses change if we were looking at

122
00:04:33,240 --> 00:04:28,900
about an abiotic methane flux versus a

123
00:04:34,740 --> 00:04:33,250
biological methane flux all right so if

124
00:04:35,549 --> 00:04:34,750
you were to look at this plot what we

125
00:04:38,789 --> 00:04:35,559
did is that we

126
00:04:41,219 --> 00:04:38,799
at these fluxes in a 1% 2% and 5% co2

127
00:04:43,319 --> 00:04:41,229
atmospheres because that's we know that

128
00:04:45,389 --> 00:04:43,329
co2 or carbon dioxide affects how meant

129
00:04:46,949 --> 00:04:45,399
they builds up in the atmosphere and as

130
00:04:48,809 --> 00:04:46,959
you can see looking at the pink line

131
00:04:50,759 --> 00:04:48,819
which is your 1% co2 atmosphere you can

132
00:04:51,959 --> 00:04:50,769
see that your methane mixing ratio is

133
00:04:53,579 --> 00:04:51,969
getting higher meaning that you have

134
00:04:55,649 --> 00:04:53,589
more methane accumulating in those

135
00:04:57,719 --> 00:04:55,659
atmospheres and thus making the methane

136
00:05:00,119 --> 00:04:57,729
very detectable whereas if you look at

137
00:05:01,919 --> 00:05:00,129
your 2% and 5% witches are your blue and

138
00:05:03,809 --> 00:05:01,929

your yellow your green line excuse me

139
00:05:05,369 --> 00:05:03,819
you can see that you have less methane

140
00:05:07,109 --> 00:05:05,379
accumulating meaning that it's orders of

141
00:05:08,939 --> 00:05:07,119
magnitudes lower than your one percent

142
00:05:10,889 --> 00:05:08,949
atmosphere me that you will need higher

143
00:05:12,169 --> 00:05:10,899
fluxes in those atmospheres in order for

144
00:05:14,729 --> 00:05:12,179
the methane to be detectable

145
00:05:16,649 --> 00:05:14,739
so in our parameters what we did is that

146
00:05:18,389 --> 00:05:16,659
we know that your zero to approximately

147
00:05:20,609 --> 00:05:18,399
10 tera moles based on Josh's paper

148
00:05:21,929 --> 00:05:20,619
initially but approximately 0 to 10 tera

149
00:05:25,289 --> 00:05:21,939
moles you can safely say those are your

150
00:05:26,579 --> 00:05:25,299
abiotic fluxes whereas we also simulate

151
00:05:28,349 --> 00:05:26,589
the earth life fluxes which is

152
00:05:29,759 --> 00:05:28,359
approximately 10 tera moles per year to

153
00:05:31,409 --> 00:05:29,769
approximately 40 tera moles which would

154
00:05:33,659 --> 00:05:31,419
be like your earth light body fluxes and

155
00:05:36,029 --> 00:05:33,669
then of course we also simulated even

156
00:05:37,769 --> 00:05:36,039
greater flux biological fluxes because

157
00:05:39,779 --> 00:05:37,779
we just frankly don't know what these

158
00:05:41,459 --> 00:05:39,789
methane budgets could be for some of

159
00:05:46,709 --> 00:05:41,469
those exoplanets and hopefully they'll

160
00:05:48,239 --> 00:05:46,719
have really cool microbes like this so

161
00:05:49,949 --> 00:05:48,249
when we take a look at the sorry excuse

162
00:05:52,709 --> 00:05:49,959
me so when we take a look at the one

163
00:05:54,839 --> 00:05:52,719

percent co2 spectra your blue line is a

164
00:05:56,879 --> 00:05:54,849
low methane flux your yellow line is a

165
00:05:58,859 --> 00:05:56,889
medium methane flux as well as your

166
00:06:00,749 --> 00:05:58,869
Green Line is the high methane flux and

167
00:06:02,009 --> 00:06:00,759
what you're seeing here is that your

168
00:06:03,359 --> 00:06:02,019
Green Line shows that you have very

169
00:06:05,429 --> 00:06:03,369
strong absorption features across

170
00:06:07,439 --> 00:06:05,439
various wavelengths showing you that

171
00:06:09,269 --> 00:06:07,449
your methane is absorbing a lot I mean

172
00:06:11,399 --> 00:06:09,279
that is detectable whereas if you're

173
00:06:13,199 --> 00:06:11,409
looking at your 1% which is your low or

174
00:06:15,599 --> 00:06:13,209
your low methane flux and your yellow

175
00:06:16,739 --> 00:06:15,609
which is the medium methane flux you

176
00:06:18,179 --> 00:06:16,749
still have strong absorption at

177
00:06:19,439 --> 00:06:18,189
different wavelengths but it's not as

178
00:06:22,319 --> 00:06:19,449
strong as you would see in very high

179
00:06:23,789 --> 00:06:22,329
methane environment methane fluxes but

180
00:06:26,129 --> 00:06:23,799
then when you look at your to person as

181
00:06:28,499 --> 00:06:26,139
your co2 is increasing you see that you

182
00:06:31,109 --> 00:06:28,509
still when you look at your high methane

183
00:06:32,159 --> 00:06:31,119
flux you can see that you have the green

184
00:06:34,589 --> 00:06:32,169
you can see that your stuff strong

185
00:06:36,599 --> 00:06:34,599
absorption at different wavelengths but

186
00:06:38,279 --> 00:06:36,609
not as strong as you would in the 1%

187
00:06:39,899 --> 00:06:38,289
whereas if you were looking at the blue

188
00:06:42,109 --> 00:06:39,909

and the yellow which is your low in your

189
00:06:43,829 --> 00:06:42,119
medium you can see that your flex or

190
00:06:45,989 --> 00:06:43,839
spectral lines are becoming almost

191
00:06:47,999 --> 00:06:45,999
indiscernible and again that same

192
00:06:48,960 --> 00:06:48,009
behavior is seen in the 5% co2

193
00:06:49,980 --> 00:06:48,970
atmosphere

194
00:06:51,480 --> 00:06:49,990
where you're still seeing strong

195
00:06:53,670 --> 00:06:51,490
absorption of the green which is the

196
00:06:55,560 --> 00:06:53,680
very high methane flux but when you look

197
00:06:57,570 --> 00:06:55,570
at your low and medium which is the blue

198
00:06:58,980 --> 00:06:57,580
and the yellow once again you can see

199
00:07:03,030 --> 00:06:58,990
that the lines are still becoming very

200
00:07:04,590 --> 00:07:03,040
indiscernible and then here what we've

201
00:07:06,270 --> 00:07:04,600
done this is where our last step which

202
00:07:07,950 --> 00:07:06,280
was where we use lavars cronograph to

203
00:07:09,810 --> 00:07:07,960
basically give us direct imagery or the

204
00:07:11,910 --> 00:07:09,820
actual process in which the observer

205
00:07:13,710 --> 00:07:11,920
would actually see these fluxes and as

206
00:07:15,720 --> 00:07:13,720
you can see that you're still seeing the

207
00:07:17,790 --> 00:07:15,730
same spectral features across various

208
00:07:19,590 --> 00:07:17,800
wavelengths but you can also take in

209
00:07:23,700 --> 00:07:19,600
combination of signal-to-noise ratio as

210
00:07:25,200 --> 00:07:23,710
well as instrument parameters so in

211
00:07:27,270 --> 00:07:25,210
conclusion what you've seen here is that

212
00:07:28,680 --> 00:07:27,280
you have high co2 and high methane which

213
00:07:30,180 --> 00:07:28,690

means that you have detectable methane

214
00:07:31,530 --> 00:07:30,190
which means that you actually have the

215
00:07:32,940 --> 00:07:31,540
signs of life which is what we want

216
00:07:35,880 --> 00:07:32,950
methane production rates that are

217
00:07:37,560 --> 00:07:35,890
comfortable to biology and then lastly

218
00:07:39,660 --> 00:07:37,570
when you have increasing atmospheric co2

219
00:07:41,280 --> 00:07:39,670
you know that you decrease the amount of

220
00:07:42,720 --> 00:07:41,290
methane is that skimming your Emma

221
00:07:45,270 --> 00:07:42,730
sphere and dust that makes your methane

222
00:07:47,040 --> 00:07:45,280
less detectable and then of course that

223
00:07:48,840 --> 00:07:47,050
when we start to think about project men

224
00:07:50,700 --> 00:07:48,850
about missions such as lovara we know

225
00:07:52,560 --> 00:07:50,710
that we can detect that methane across

226
00:07:55,980 --> 00:07:52,570
various wavelengths and there when you

227
00:07:57,330 --> 00:07:55,990
have very high methane so as our future

228
00:07:58,800 --> 00:07:57,340
directions been moving forward what we

229
00:08:00,840 --> 00:07:58,810
hope to do is that we're going to change

230
00:08:03,510 --> 00:08:00,850
the parent star so in this case we are

231
00:08:05,820 --> 00:08:03,520
dealing with our qiansun we have tipless

232
00:08:07,890 --> 00:08:05,830
in our model that allow us to model

233
00:08:09,810 --> 00:08:07,900
indoor such as ad leo and Proxima

234
00:08:11,190 --> 00:08:09,820
Centauri and we know that those type

235
00:08:12,540 --> 00:08:11,200
when you change those start stellar

236
00:08:14,330 --> 00:08:12,550
types we know that they can change the

237
00:08:16,740 --> 00:08:14,340
spectral features that you're seeing

238
00:08:17,760 --> 00:08:16,750

another thing that we can also do is

239
00:08:19,260 --> 00:08:17,770
that we're looking at changing the

240
00:08:21,360 --> 00:08:19,270
planetary distance from the parent star

241
00:08:23,640 --> 00:08:21,370
which in that case what we do is that

242
00:08:25,560 --> 00:08:23,650
we're currently at 1 au which is where

243
00:08:27,510 --> 00:08:25,570
Earth is currently and that when you

244
00:08:30,480 --> 00:08:27,520
also change those pros distance between

245
00:08:32,190 --> 00:08:30,490
the star between the star you know that

246
00:08:34,980 --> 00:08:32,200
you can also see different spectral

247
00:08:36,750 --> 00:08:34,990
features as well and then lastly another

248
00:08:38,760 --> 00:08:36,760
long term goals that we could actually

249
00:08:40,230 --> 00:08:38,770
use an Earth System model known as genie

250
00:08:41,969 --> 00:08:40,240
it's actually Spore the boundary

251
00:08:46,800 --> 00:08:41,979
conditions for what it called for a body

252
00:08:54,060 --> 00:08:46,810
methane production and then I'm ready

253
00:09:15,220 --> 00:09:11,260
Thank You Alina questions I think it's

254
00:09:18,210 --> 00:09:15,230
all ok

255
00:09:21,610 --> 00:09:18,220
David Kaplan University of Washington so

256
00:09:23,889 --> 00:09:21,620
on the the paper that Josh croissants

257
00:09:26,889 --> 00:09:23,899
and Taunton did I'm he said I was his

258
00:09:30,760 --> 00:09:26,899
advisor we also talked about carbon

259
00:09:32,470 --> 00:09:30,770
monoxide and the idea was that on a

260
00:09:35,860 --> 00:09:32,480
biological planet it should get eaten

261
00:09:37,269 --> 00:09:35,870
and so if it's less than about 100 ppm I

262
00:09:40,360 --> 00:09:37,279
mean it depends on the spectrum of the

263
00:09:42,370 --> 00:09:40,370

star as Eddy sweetie Moniz looked at but

264
00:09:44,010 --> 00:09:42,380
is that something else that maybe you

265
00:09:46,510 --> 00:09:44,020
could you could also consider that

266
00:09:49,000 --> 00:09:46,520
because if it's if it's very high at Sur

267
00:09:51,250 --> 00:09:49,010
sort of anti bio signature and if it's

268
00:09:53,800 --> 00:09:51,260
very low that's consistent with biology

269
00:09:55,990 --> 00:09:53,810
so there's an additional diagnostic that

270
00:09:58,780 --> 00:09:56,000
you can use besides the high methane

271
00:10:00,340 --> 00:09:58,790
levels and so it's just a comment really

272
00:10:02,410 --> 00:10:00,350
that that would also be an interesting

273
00:10:03,760 --> 00:10:02,420
thing to look at and thanks very much

274
00:10:11,440 --> 00:10:03,770
for your talk by the way which is very

275
00:10:13,630 --> 00:10:11,450
clear very nice yeah thank you thank you

276
00:10:15,660 --> 00:10:13,640
for your time and I appreciate have an