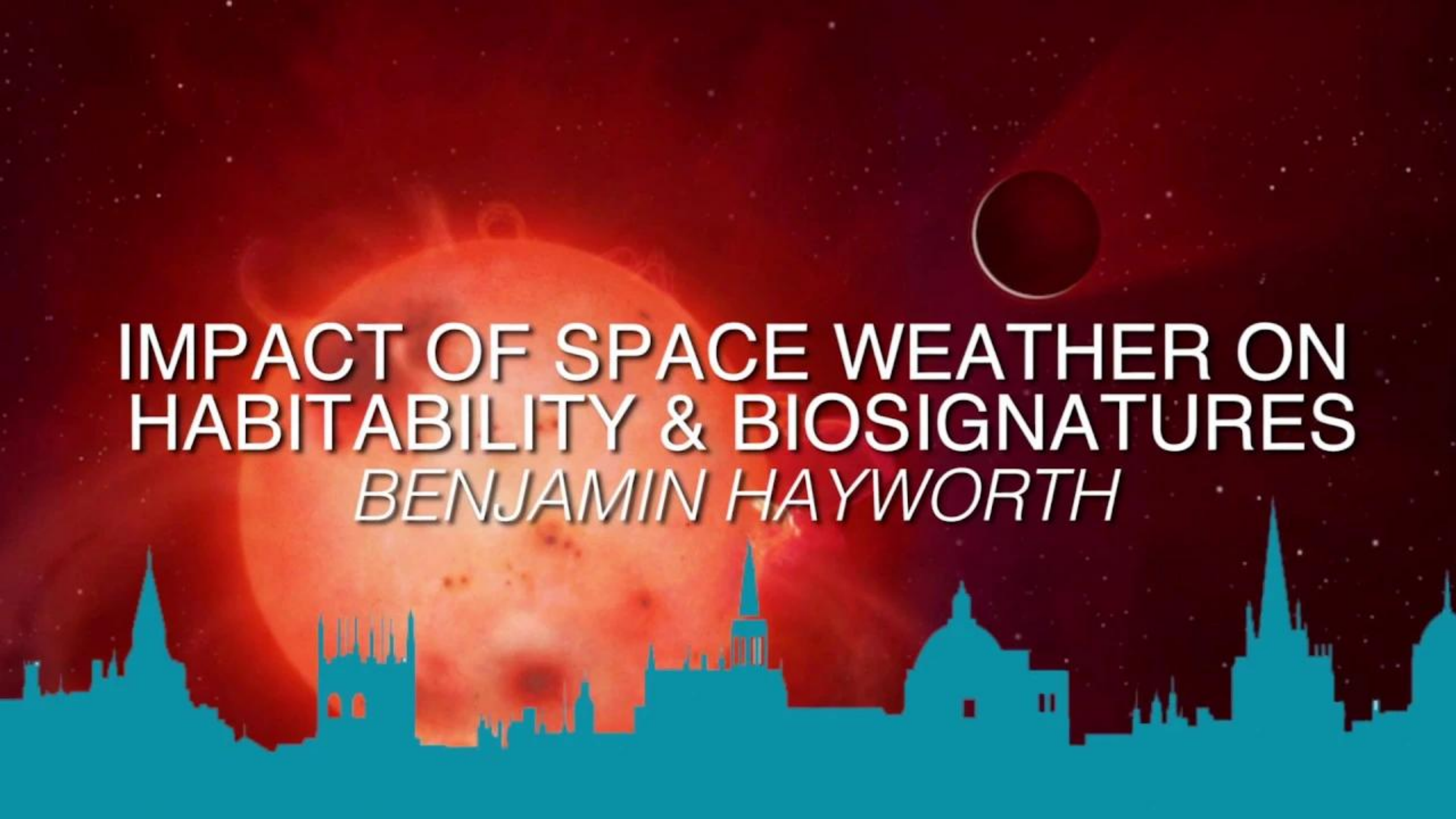
IMPACT OF SPACE WEATHER ON
HABITABILITY & BIOSIGNATURES
BENJAMIN HAYWORTH

1
00:00:08,799 --> 00:00:06,809
[Music]

2
00:00:11,129 --> 00:00:08,809
howdy my name is Ben Hayworth

3
00:00:13,690 --> 00:00:11,139
I'm a graduate student at Penn State and

4
00:00:15,100 --> 00:00:13,700
thank you to the conveners for giving me

5
00:00:17,170 --> 00:00:15,110
the opportunity to talk about this

6
00:00:19,300 --> 00:00:17,180
project that I quite literally just

7
00:00:21,609 --> 00:00:19,310
started so if you like some of the

8
00:00:22,840 --> 00:00:21,619
predictions about this that I'm making

9
00:00:26,650 --> 00:00:22,850
you should come to age you to see the

10
00:00:28,179 --> 00:00:26,660
final results alright so in general the

11
00:00:30,700 --> 00:00:28,189
project I'm looking at is whether or not

12
00:00:32,950 --> 00:00:30,710
space weather can impact an exoplanets

13
00:00:34,360 --> 00:00:32,960

atmospheric chemistry on such a level

14
00:00:36,369 --> 00:00:34,370
that you then can affect its

15
00:00:38,860 --> 00:00:36,379
habitability and perhaps future

16
00:00:40,869 --> 00:00:38,870
observations of that planet so I am

17
00:00:42,880 --> 00:00:40,879
currently in everyone's favorite part of

18
00:00:44,260 --> 00:00:42,890
a project model development so I'm kind

19
00:00:46,630 --> 00:00:44,270
of stuck right now up in those first two

20
00:00:55,200 --> 00:00:46,640
boxes but that's not what's driving the

21
00:01:02,259 --> 00:00:58,630
appreciative that's that's much better

22
00:01:03,910 --> 00:01:02,269
okay all right so I'm right now stuck in

23
00:01:05,710 --> 00:01:03,920
those first two boxes but what's driving

24
00:01:08,020 --> 00:01:05,720
it are the potential implications of

25
00:01:09,969 --> 00:01:08,030
this so the first one which has been

26
00:01:12,100 --> 00:01:09,979
explored by another group is that space

27
00:01:14,260 --> 00:01:12,110
weather can potentially build up a

28
00:01:16,510 --> 00:01:14,270
biotic lees nitrous oxide on your planet

29
00:01:18,940 --> 00:01:16,520
which is a potent greenhouse gas so it

30
00:01:21,219 --> 00:01:18,950
can radiatively force it and then I put

31
00:01:23,230 --> 00:01:21,229
plus haze there because nitrous oxide we

32
00:01:24,999 --> 00:01:23,240
find that our preliminary results has a

33
00:01:26,830 --> 00:01:25,009
very interesting relationship with

34
00:01:29,469 --> 00:01:26,840
organic haze that you build up on your

35
00:01:30,880 --> 00:01:29,479
planet and both of those impacts the

36
00:01:32,800 --> 00:01:30,890
habitability of the planets we want to

37
00:01:36,190 --> 00:01:32,810
explore that relationship further over a

38
00:01:38,919 --> 00:01:36,200

wide sweep of parameter space now I also

39
00:01:41,529 --> 00:01:38,929
put observations because one like secret

40
00:01:43,660 --> 00:01:41,539
said n2o is a potential bio signature on

41
00:01:45,639 --> 00:01:43,670
modern-day earth the only two processes

42
00:01:48,370 --> 00:01:45,649
that really build up n2o is lightning

43
00:01:51,580 --> 00:01:48,380
and life and if we are able to abiotic

44
00:01:53,109 --> 00:01:51,590
we build it up with another process we

45
00:01:54,999 --> 00:01:53,119
should look at whether or not that is a

46
00:01:56,650 --> 00:01:55,009
good bio signature and also what

47
00:01:58,180 --> 00:01:56,660
environments can it build up it turns

48
00:01:59,800 --> 00:01:58,190
out space weather may not be able to

49
00:02:01,540 --> 00:01:59,810
build up into Oh in certain environments

50
00:02:04,270 --> 00:02:01,550
but it can and others and that's

51
00:02:06,070 --> 00:02:04,280
something we want to explore and finally

52
00:02:07,600 --> 00:02:06,080
this one's more speculative but this is

53
00:02:09,580 --> 00:02:07,610
what actually got me thinking about this

54
00:02:11,170 --> 00:02:09,590
problem was right now we talk a lot

55
00:02:13,510 --> 00:02:11,180
about whether a magnetic field is

56
00:02:15,910 --> 00:02:13,520
necessary or impacts the habitability of

57
00:02:18,100 --> 00:02:15,920
an exoplanet but at least for us triol

58
00:02:20,050 --> 00:02:18,110
ones we have no way of detecting them

59
00:02:23,250 --> 00:02:20,060
it's well below any detection threshold

60
00:02:26,020 --> 00:02:23,260
we can think of but if we know a process

61
00:02:27,820 --> 00:02:26,030
that impacts the atmospheric chemistry

62
00:02:29,860 --> 00:02:27,830
of a planet and can potentially be

63
00:02:31,869 --> 00:02:29,870

buffered by that planet's magnetic field

64
00:02:33,640 --> 00:02:31,879
we could use that as a proxy for

65
00:02:36,970 --> 00:02:33,650
inferring whether or not these planets

66
00:02:38,440 --> 00:02:36,980
may have magnetic field all right so I

67
00:02:40,270 --> 00:02:38,450
keep saying space weather what am I

68
00:02:42,490 --> 00:02:40,280
talking about I'm talking about

69
00:02:44,589 --> 00:02:42,500
solar proton events those that follow

70
00:02:47,619 --> 00:02:44,599
coronal mass ejections so this is one

71
00:02:50,410 --> 00:02:47,629
for our own Sun in 2012 what these are

72
00:02:51,849 --> 00:02:50,420
they're very magnetically active events

73
00:02:53,830 --> 00:02:51,859
where the star will shed some of its

74
00:02:55,839 --> 00:02:53,840
coronal mass in the form of a plasma

75
00:02:58,660 --> 00:02:55,849
stream these streams are going to be

76
00:03:00,220 --> 00:02:58,670
very high number density high-energy

77
00:03:02,170 --> 00:03:00,230
charged particles and they

78
00:03:05,050 --> 00:03:02,180
preferentially occur in the axis of

79
00:03:07,210 --> 00:03:05,060
rotation of your star so for systems

80
00:03:10,390 --> 00:03:07,220
that aren't that misaligned this will

81
00:03:12,369 --> 00:03:10,400
also hit your planets it depends on how

82
00:03:14,199 --> 00:03:12,379
active the star is our star right now is

83
00:03:18,220 --> 00:03:14,209
pretty quiet but we know a lot of em

84
00:03:19,509 --> 00:03:18,230
dwarves that are very active now it's

85
00:03:21,759 --> 00:03:19,519
also been proposed that potentially

86
00:03:22,930 --> 00:03:21,769
magnetic fields can shield you from this

87
00:03:24,370 --> 00:03:22,940
that's actually one of their arguments

88
00:03:27,190 --> 00:03:24,380

why they might be good for habitability

89
00:03:28,839 --> 00:03:27,200
this right here from the other group

90
00:03:31,180 --> 00:03:28,849
I'll mention in a second this was a

91
00:03:33,369 --> 00:03:31,190
Carrington like event modeled against

92
00:03:35,199 --> 00:03:33,379
modern day Earth's magnetic field the

93
00:03:36,729 --> 00:03:35,209
white lines are our magnetic field lines

94
00:03:39,610 --> 00:03:36,739
and you'll see that it's actually able

95
00:03:41,349 --> 00:03:39,620
to shear the Earth's magnetic field open

96
00:03:43,629 --> 00:03:41,359
enough that more of these particles can

97
00:03:45,729 --> 00:03:43,639
make it n so I'm not gonna be talking

98
00:03:47,879 --> 00:03:45,739
about solar wind the reason for that is

99
00:03:50,770 --> 00:03:47,889
that's constantly buffeting the Earth's

100
00:03:52,509 --> 00:03:50,780
magnetic or atmosphere and it's not

101
00:03:54,220 --> 00:03:52,519
really driving any chemistry mainly

102
00:03:56,349 --> 00:03:54,230
because those particles are typically

103
00:03:58,599 --> 00:03:56,359
slow enough energy that they're

104
00:04:00,490 --> 00:03:58,609
deflected by our magnetic field and even

105
00:04:02,550 --> 00:04:00,500
those that are able to make it in lose

106
00:04:07,539 --> 00:04:02,560
their energy well above 100 kilometers

107
00:04:09,309 --> 00:04:07,549
in most cases all right so what kind of

108
00:04:11,589 --> 00:04:09,319
chemistry are these high-energy

109
00:04:13,960 --> 00:04:11,599
particles able to drive it's relatively

110
00:04:15,430 --> 00:04:13,970
simple it's just splitting n2 which is a

111
00:04:17,650 --> 00:04:15,440
very difficult thing to do in the modern

112
00:04:19,449 --> 00:04:17,660
atmosphere so like I said lightning down

113
00:04:21,699 --> 00:04:19,459

in the troposphere is able to split n2

114
00:04:24,129 --> 00:04:21,709
it's a really difficult triple bond and

115
00:04:25,959 --> 00:04:24,139
we don't readily photolyze and - in the

116
00:04:27,850 --> 00:04:25,969
lower atmosphere the reason for that is

117
00:04:31,390 --> 00:04:27,860
the wavelengths that are able to make it

118
00:04:32,890 --> 00:04:31,400
into our mid altitudes

119
00:04:35,350 --> 00:04:32,900
the absorption cross-section for

120
00:04:37,420 --> 00:04:35,360
ionization and dissociation friend two

121
00:04:39,670 --> 00:04:37,430
are relatively similar so we end up is

122
00:04:41,590 --> 00:04:39,680
amend two but not really dissociating it

123
00:04:43,330 --> 00:04:41,600
so what occurs is these high-energy

124
00:04:44,050 --> 00:04:43,340
protons are able to make it into the

125
00:04:46,090 --> 00:04:44,060
atmosphere

126
00:04:48,550 --> 00:04:46,100
they will ionize the neutral gas around

127
00:04:50,170 --> 00:04:48,560
them and then the subsequent secondary

128
00:04:52,090 --> 00:04:50,180
electrons then have the correct

129
00:04:54,430 --> 00:04:52,100
cross-sections and energies the split

130
00:04:55,629 --> 00:04:54,440
end to and once you split end to it can

131
00:04:58,060 --> 00:04:55,639
stick the other things like hydrogen

132
00:05:01,780 --> 00:04:58,070
it's very reactive and you end up

133
00:05:04,180 --> 00:05:01,790
getting n 2o or h ZN usually not both of

134
00:05:06,340 --> 00:05:04,190
them and that depends on your your

135
00:05:08,650 --> 00:05:06,350
background atmosphere so this process

136
00:05:11,350 --> 00:05:08,660
had previously been explored by aaron at

137
00:05:13,360 --> 00:05:11,360
all in 2016 it's a very exciting idea

138
00:05:15,370 --> 00:05:13,370

the space weather can drive atmospheric

139
00:05:17,950 --> 00:05:15,380
chemistry so they used a very

140
00:05:20,560 --> 00:05:17,960
sophisticated magneto hydrodynamic model

141
00:05:22,779 --> 00:05:20,570
to calculate these particle fluxes at

142
00:05:23,920 --> 00:05:22,789
the top of the planet's atmosphere how

143
00:05:26,379 --> 00:05:23,930
many are able to make it through the

144
00:05:29,260 --> 00:05:26,389
magnetic field and then down into it and

145
00:05:30,400 --> 00:05:29,270
then they used a sort of a box chemical

146
00:05:32,469 --> 00:05:30,410
model to see what happened

147
00:05:34,810 --> 00:05:32,479
so these are some profiles from their

148
00:05:37,480 --> 00:05:34,820
chemical model and they found that in

149
00:05:39,700 --> 00:05:37,490
the mid altitudes like say 30 to 40

150
00:05:42,490 --> 00:05:39,710
kilometers they could get parts per

151
00:05:45,760 --> 00:05:42,500
million of nitrous oxide which is enough

152
00:05:47,440 --> 00:05:45,770
for it to be radiatively effective now

153
00:05:49,000 --> 00:05:47,450
what we want to do is go back and look

154
00:05:50,500 --> 00:05:49,010
at this process but there were some

155
00:05:52,659 --> 00:05:50,510
physics missing in the original chemical

156
00:05:54,490 --> 00:05:52,669
model so we want to explore that because

157
00:05:57,550 --> 00:05:54,500
a lot of this is very important for n2

158
00:05:59,020 --> 00:05:57,560
the first one is fatalis so originally

159
00:06:01,750 --> 00:05:59,030
was used and optimistic and a

160
00:06:04,570 --> 00:06:01,760
pessimistic photo destruction rate turns

161
00:06:07,300 --> 00:06:04,580
out when you look at n 2o wavelength by

162
00:06:09,700 --> 00:06:07,310
wavelength then it very very readily

163
00:06:12,730 --> 00:06:09,710

wants to photo dissociate at almost any

164
00:06:15,129 --> 00:06:12,740
UV wavelength so that's something you

165
00:06:17,589 --> 00:06:15,139
have to consider also convection so a

166
00:06:20,650 --> 00:06:17,599
lot of these high-energy particles again

167
00:06:22,000 --> 00:06:20,660
they will fall off with pressure as they

168
00:06:24,250 --> 00:06:22,010
enter the atmosphere so you'll be doing

169
00:06:25,629 --> 00:06:24,260
a lot of this chemistry high up and then

170
00:06:28,270 --> 00:06:25,639
less and less as you work your way down

171
00:06:29,260 --> 00:06:28,280
so mixing processes are important to

172
00:06:32,650 --> 00:06:29,270
consider when you're doing this

173
00:06:34,930 --> 00:06:32,660
chemistry third is organic haze so I

174
00:06:37,480 --> 00:06:34,940
just said n2o likes to fertilize very

175
00:06:39,129 --> 00:06:37,490
easily and you need something to shield

176
00:06:41,230 --> 00:06:39,139
it so we're thinking what could shield

177
00:06:43,390 --> 00:06:41,240
it out to those wavelengths and organic

178
00:06:45,200 --> 00:06:43,400
haze if it's thick enough is very

179
00:06:47,540 --> 00:06:45,210
capable of shielding in the UV

180
00:06:49,580 --> 00:06:47,550
I put fractal up here just because

181
00:06:51,620 --> 00:06:49,590
people that typically model Hayes know

182
00:06:53,180 --> 00:06:51,630
that it's not nice little spheres that

183
00:06:55,129 --> 00:06:53,190
you model when it's scattering it

184
00:06:56,570 --> 00:06:55,139
typically aggregates into gross

185
00:06:58,939 --> 00:06:56,580
geometries which will pretend are

186
00:07:01,340 --> 00:06:58,949
fractals and that makes it a very

187
00:07:03,529 --> 00:07:01,350
effective scatterer in the UV so it

188
00:07:07,249 --> 00:07:03,539

allows it to shield out further

189
00:07:07,969 --> 00:07:07,259
wavelengths and then finally ion

190
00:07:09,620 --> 00:07:07,979
chemistry

191
00:07:10,939 --> 00:07:09,630
so I just said these protons as they

192
00:07:13,189 --> 00:07:10,949
come through the atmosphere they'll be

193
00:07:15,020 --> 00:07:13,199
producing secondary electrons that

194
00:07:18,020 --> 00:07:15,030
ionizes the background neutral

195
00:07:19,879 --> 00:07:18,030
atmosphere and while it's short-lived

196
00:07:22,010 --> 00:07:19,889
it's on the similar time skills as these

197
00:07:23,749 --> 00:07:22,020
chemical reactions and the reactive

198
00:07:25,010 --> 00:07:23,759
cross-sections for those ions are

199
00:07:27,260 --> 00:07:25,020
considerably different than their

200
00:07:28,279 --> 00:07:27,270
neutral counterparts so these are you

201
00:07:30,140 --> 00:07:28,289
know the physics that we're gonna be

202
00:07:32,180 --> 00:07:30,150
throwing in the model that I'm currently

203
00:07:33,920 --> 00:07:32,190
working on okay

204
00:07:36,110 --> 00:07:33,930
so I'll run through this real quick so

205
00:07:37,520 --> 00:07:36,120
this is the boring part but I can't get

206
00:07:39,230 --> 00:07:37,530
a thesis doing this on the back of a

207
00:07:42,650 --> 00:07:39,240
cocktail laughing I have to show that I

208
00:07:44,390 --> 00:07:42,660
did some science so we'll be looking at

209
00:07:46,310 --> 00:07:44,400
how efficiently these particles are able

210
00:07:48,200 --> 00:07:46,320
to propagate through the atmosphere once

211
00:07:49,730 --> 00:07:48,210
we know their fluxes by altitude we can

212
00:07:52,010 --> 00:07:49,740
then run them through our chemical model

213
00:07:53,540 --> 00:07:52,020

to know how much of this chemistry is

214
00:07:57,529 --> 00:07:53,550
actually going to be driven do we end up

215
00:07:59,000 --> 00:07:57,539
with m2o hcn haze and then we also do

216
00:08:01,279 --> 00:07:59,010
care about the habitability so we can

217
00:08:03,170 --> 00:08:01,289
then take those profiles mixing ratio

218
00:08:05,240 --> 00:08:03,180
profiles and run them through a 1d

219
00:08:06,469 --> 00:08:05,250
radiative convective model to see if

220
00:08:08,629 --> 00:08:06,479
they have any effect on the surface

221
00:08:10,520 --> 00:08:08,639
temperature and finally I did mention

222
00:08:12,110 --> 00:08:10,530
that in the future we want to think of

223
00:08:15,140 --> 00:08:12,120
what these signals would mean

224
00:08:17,420 --> 00:08:15,150
observational II so we can use smart or

225
00:08:19,249 --> 00:08:17,430
PSG which we've currently been looking

226
00:08:20,870 --> 00:08:19,259
at to generate spectra using those

227
00:08:25,010 --> 00:08:20,880
pressure temperature in the exterior

228
00:08:27,379 --> 00:08:25,020
profiles okay so I said n2l readily

229
00:08:28,670 --> 00:08:27,389
photolyze --is the left plot right here

230
00:08:30,860 --> 00:08:28,680
that red line is the absorption

231
00:08:32,930 --> 00:08:30,870
cross-section for nitrous oxide and

232
00:08:35,300 --> 00:08:32,940
these black lines right here are the

233
00:08:37,130 --> 00:08:35,310
fraction of its catalysis per wavelength

234
00:08:38,719 --> 00:08:37,140
then and just right up front I'll tell

235
00:08:41,120 --> 00:08:38,729
you both of those curves integrates to

236
00:08:42,980 --> 00:08:41,130
about one so almost all the Anto you

237
00:08:45,829 --> 00:08:42,990
build up immediately photolyze it's in

238
00:08:47,720 --> 00:08:45,839

UV the black solid lines at the top of

239
00:08:49,310 --> 00:08:47,730
the atmosphere so it's photolyze anova

240
00:08:51,590 --> 00:08:49,320
its entire range that's because there's

241
00:08:53,210 --> 00:08:51,600
nothing shielding it and and down in the

242
00:08:55,910 --> 00:08:53,220
troposphere I believe this was 15

243
00:08:58,280 --> 00:08:55,920
kilometers none of its fertilizing outs

244
00:08:59,030 --> 00:08:58,290
of 2009 strums that's because co2 is

245
00:09:01,250 --> 00:08:59,040
ineffective she

246
00:09:03,319 --> 00:09:01,260
and then immediately after it everything

247
00:09:04,970 --> 00:09:03,329
fertilizes we tried to think what can we

248
00:09:06,639 --> 00:09:04,980
put that can shield it out to at least

249
00:09:09,319 --> 00:09:06,649
2500 angstroms

250
00:09:11,509 --> 00:09:09,329
so we tried methane like the previous

251
00:09:15,310 --> 00:09:11,519
authors had proposed methane though

252
00:09:16,519 --> 00:09:15,320
while it dissociates under UV it is not

253
00:09:20,569 --> 00:09:16,529
effective

254
00:09:22,069 --> 00:09:20,579
past like 1700 angstroms so this plot

255
00:09:23,780 --> 00:09:22,079
right here is we were just taking upper

256
00:09:25,639 --> 00:09:23,790
fluxes from the previous air peach

257
00:09:27,769 --> 00:09:25,649
nettles group plugging them in and

258
00:09:29,689 --> 00:09:27,779
seeing can we get any of this to connect

259
00:09:32,210 --> 00:09:29,699
down and then be shielded by methane

260
00:09:34,639 --> 00:09:32,220
this was an unrealistically methane

261
00:09:38,540 --> 00:09:34,649
heavy case I was like a 20% mixing ratio

262
00:09:41,030 --> 00:09:38,550
of methane on the planet all right but

263
00:09:43,639 --> 00:09:41,040

can hey shield it the answer is yes

264
00:09:45,319 --> 00:09:43,649
so after stare suck I feel like I should

265
00:09:46,730 --> 00:09:45,329
talk about different kinds of Hayes's

266
00:09:48,439 --> 00:09:46,740
than the one in this model but it is

267
00:09:49,970 --> 00:09:48,449
just a hydrocarbon haze that's what we

268
00:09:52,370 --> 00:09:49,980
currently have optical properties for

269
00:09:55,220 --> 00:09:52,380
but I'd be excited don't get nitrogen

270
00:09:58,040 --> 00:09:55,230
very Hayes's okay so in our model what

271
00:10:00,500 --> 00:09:58,050
we do is we build up a hydrocarbon haze

272
00:10:03,170 --> 00:10:00,510
by adjusting the methane to co2 ratio

273
00:10:05,509 --> 00:10:03,180
under a UV environment and so this is

274
00:10:07,280 --> 00:10:05,519
very relatively thick haze you'll see at

275
00:10:09,680 --> 00:10:07,290
the top of the atmosphere and at 75

276
00:10:12,050 --> 00:10:09,690
kilometers almost none of our UV energy

277
00:10:13,759 --> 00:10:12,060
is lost once you get to 50 kilometers

278
00:10:16,250 --> 00:10:13,769
you start to just dip below that haze

279
00:10:18,019 --> 00:10:16,260
deck and then down at 25 in the surface

280
00:10:21,019 --> 00:10:18,029
almost none of the UV makes it down

281
00:10:24,050 --> 00:10:21,029
there so organic haze can be an

282
00:10:25,610 --> 00:10:24,060
effective shield for this now what does

283
00:10:27,410 --> 00:10:25,620
this mean for habitability we know that

284
00:10:30,110 --> 00:10:27,420
we need a is to shield n2o and we know

285
00:10:32,840 --> 00:10:30,120
that n2o can radiatively force the

286
00:10:34,340 --> 00:10:32,850
climate so the previous work was done

287
00:10:36,170 --> 00:10:34,350
for the early Earth here peach natal

288
00:10:38,059 --> 00:10:36,180

group wanted to answer the fam Sun

289
00:10:39,740 --> 00:10:38,069
paradox if we had a more active young

290
00:10:42,019 --> 00:10:39,750
star could we potentially warm it with

291
00:10:43,639 --> 00:10:42,029
this n2o and that seems like a natural

292
00:10:45,379 --> 00:10:43,649
place to start since we have a different

293
00:10:47,600 --> 00:10:45,389
suite of models and it's always good to

294
00:10:49,579 --> 00:10:47,610
retest hypotheses I throw up an orange

295
00:10:51,949 --> 00:10:49,589
earth because I'm gonna pretend early

296
00:10:54,800 --> 00:10:51,959
Earth was hazy if you disagree don't

297
00:10:56,389 --> 00:10:54,810
know I need it for this all right and

298
00:10:57,769 --> 00:10:56,399
then also early Mars we have problem

299
00:10:59,600 --> 00:10:57,779
warming that so it's a natural next step

300
00:11:01,069 --> 00:10:59,610
but this is EXO climb so we care about

301
00:11:02,509 --> 00:11:01,079
exoplanets and this is where it's going

302
00:11:04,939 --> 00:11:02,519
to be really interesting to explore the

303
00:11:06,259 --> 00:11:04,949
relationship between haze and n2l so I

304
00:11:08,199 --> 00:11:06,269
put the trap is system up here on

305
00:11:10,670 --> 00:11:08,209
purpose because it's orbiting an M dwarf

306
00:11:12,800 --> 00:11:10,680
very active stars they'll have very

307
00:11:14,750 --> 00:11:12,810
frequent coronal mass ejections

308
00:11:16,930 --> 00:11:14,760
and also they are all orbiting very

309
00:11:19,010 --> 00:11:16,940
close to the star not only will you

310
00:11:21,350 --> 00:11:19,020
experience more of these high-energy

311
00:11:23,540 --> 00:11:21,360
particles but more than will interact

312
00:11:24,920 --> 00:11:23,550
with the atmosphere and they potentially

313
00:11:26,630 --> 00:11:24,930

don't have magnetic fields at least

314
00:11:28,160 --> 00:11:26,640
that's what most people think right now

315
00:11:31,040 --> 00:11:28,170
so you shouldn't have any mitigation

316
00:11:33,110 --> 00:11:31,050
from that all right so let's say we have

317
00:11:34,910 --> 00:11:33,120
a very active star and we want to see

318
00:11:36,769 --> 00:11:34,920
how this plays out you've a very active

319
00:11:38,570 --> 00:11:36,779
star you're gonna have more coronal mass

320
00:11:41,150 --> 00:11:38,580
ejections more of these particles in the

321
00:11:45,470 --> 00:11:41,160
atmosphere true you're also gonna have a

322
00:11:47,570 --> 00:11:45,480
higher XUV flux from flares now this

323
00:11:48,769 --> 00:11:47,580
step is very compositionally dependent

324
00:11:50,390 --> 00:11:48,779
and this is where a large sweep over

325
00:11:52,460 --> 00:11:50,400
parameter space is necessary for

326
00:11:54,530 --> 00:11:52,470
exoplanets on the right here I said

327
00:11:56,660 --> 00:11:54,540
having a higher xev flux means you'll

328
00:11:58,579 --> 00:11:56,670
have more organic haze that is heavily

329
00:12:01,130 --> 00:11:58,589
dependent on you having those precursor

330
00:12:02,990 --> 00:12:01,140
molecules in your atmosphere at least in

331
00:12:04,730 --> 00:12:03,000
our model that would be a methane to co2

332
00:12:06,380 --> 00:12:04,740
ratio so if you have a lot of methane

333
00:12:08,840 --> 00:12:06,390
you have enough of that to break apart

334
00:12:12,170 --> 00:12:08,850
into CH very reactive you'll start to

335
00:12:14,510 --> 00:12:12,180
form those haze aggregates now on the

336
00:12:17,030 --> 00:12:14,520
Left more n2o is produced that is also

337
00:12:19,550 --> 00:12:17,040
generally true if this original

338
00:12:21,200 --> 00:12:19,560

hypothesis is correct however it's going

339
00:12:23,030 --> 00:12:21,210
to depend on the seed Oh ratio of your

340
00:12:26,240 --> 00:12:23,040
atmosphere so there's a critical point

341
00:12:29,270 --> 00:12:26,250
where if you have too much carbon to

342
00:12:32,030 --> 00:12:29,280
oxygen you're gonna be forming HCM

343
00:12:34,430 --> 00:12:32,040
rather than nitrous oxide so there is a

344
00:12:36,050 --> 00:12:34,440
minimum threshold amount of methane we

345
00:12:37,910 --> 00:12:36,060
need to start building a haze but there

346
00:12:40,130 --> 00:12:37,920
might also be a maximum threshold for

347
00:12:41,840 --> 00:12:40,140
you'll be creating a gas that's not

348
00:12:43,220 --> 00:12:41,850
radiatively important still an

349
00:12:44,780 --> 00:12:43,230
interesting gas especially if you like

350
00:12:48,200 --> 00:12:44,790
prebiotic chemistry but not for

351
00:12:49,970 --> 00:12:48,210
habitability and we know hazel have a

352
00:12:52,310 --> 00:12:49,980
positive relationship with n 12 you need

353
00:12:54,020 --> 00:12:52,320
something to shield it now in general

354
00:12:55,280 --> 00:12:54,030
both of those will have opposing impacts

355
00:12:57,320 --> 00:12:55,290
on the planet if we're forming these

356
00:13:00,110 --> 00:12:57,330
really thick Hayes's that are necessary

357
00:13:01,520 --> 00:13:00,120
to form nitrous oxide they're also going

358
00:13:04,280 --> 00:13:01,530
to effectively raise the planetary

359
00:13:06,260 --> 00:13:04,290
albedo which cools the surface while n

360
00:13:07,400 --> 00:13:06,270
2o is a greenhouse gas it'll act to warm

361
00:13:09,290 --> 00:13:07,410
it and I have no idea what the

362
00:13:10,550 --> 00:13:09,300
magnitudes of those two are competing

363
00:13:12,079 --> 00:13:10,560

against one another and that's something

364
00:13:14,660 --> 00:13:12,089
that we definitely want to explore in

365
00:13:17,720 --> 00:13:14,670
this all right now I talked about

366
00:13:19,880 --> 00:13:17,730
observations n2o is a potential bio

367
00:13:22,670 --> 00:13:19,890
signature I'm not a biologist but notice

368
00:13:25,400 --> 00:13:22,680
through nitrate reduction and n2 it does

369
00:13:26,630 --> 00:13:25,410
have a nice absorption feature 4.5

370
00:13:30,920 --> 00:13:26,640
microns which is

371
00:13:33,380 --> 00:13:30,930
eventually observable potentially now

372
00:13:34,580 --> 00:13:33,390
this on the surface makes it seem like

373
00:13:36,410 --> 00:13:34,590
oh and tulle might be a bad bio

374
00:13:38,030 --> 00:13:36,420
signature but like we just said that

375
00:13:39,860 --> 00:13:38,040
might depend on the atmosphere so if we

376
00:13:42,590 --> 00:13:39,870
have a very you see an atmosphere that's

377
00:13:44,210 --> 00:13:42,600
very hazy and you like very hazy and you

378
00:13:45,620 --> 00:13:44,220
see nitrous oxide and I say that

379
00:13:48,320 --> 00:13:45,630
tongue-in-cheek saying you can see a

380
00:13:49,610 --> 00:13:48,330
signature and it's very hazy you know

381
00:13:52,100 --> 00:13:49,620
that maybe space weather would be

382
00:13:54,290 --> 00:13:52,110
producing HCN abiotic li non nitrous

383
00:13:56,630 --> 00:13:54,300
oxide so maybe it's still a good bio

384
00:13:58,760 --> 00:13:56,640
signature on that kind of atmosphere so

385
00:13:59,750 --> 00:13:58,770
it really depends on that's and we want

386
00:14:01,340 --> 00:13:59,760
to explore the difference between the

387
00:14:03,350 --> 00:14:01,350
background oxidized atoms for your

388
00:14:07,250 --> 00:14:03,360

bursts reduced because that'll also give

389
00:14:08,600 --> 00:14:07,260
you different phases alright and finally

390
00:14:10,910 --> 00:14:08,610
this was the more speculative one

391
00:14:13,250 --> 00:14:10,920
whether or not you could use this as a

392
00:14:14,150 --> 00:14:13,260
proxy for a magnetic field and to do

393
00:14:15,980 --> 00:14:14,160
that we would really have to know how

394
00:14:18,440 --> 00:14:15,990
many of these energy solar energetic

395
00:14:20,660 --> 00:14:18,450
particles are buffered by the planet

396
00:14:23,120 --> 00:14:20,670
having a magnetic field versus not so if

397
00:14:25,970 --> 00:14:23,130
you see a planet that you think I'd have

398
00:14:29,060 --> 00:14:25,980
a Geo Dynamo around a very active star

399
00:14:30,560 --> 00:14:29,070
and it has a haze but no HCN maybe that

400
00:14:32,180 --> 00:14:30,570
means none of those particles are making

401
00:14:34,490 --> 00:14:32,190
it down into the lower atmosphere and

402
00:14:36,260 --> 00:14:34,500
can drive that chemistry that's very

403
00:14:39,190 --> 00:14:36,270
speculative but that's at least why I

404
00:14:42,230 --> 00:14:39,200
found it exciting to begin with and

405
00:15:01,450 --> 00:14:42,240
those are my conclusions and I'll take

406
00:15:08,260 --> 00:15:04,550
what are what the photochemical lifetime

407
00:15:12,710 --> 00:15:08,270
of nitrous with and without a haze out

408
00:15:14,120 --> 00:15:12,720
haze it is I know it's about three to

409
00:15:18,050 --> 00:15:14,130
four orders of magnitude difference but

410
00:15:26,210 --> 00:15:18,060
I don't remember the actual numbers okay

411
00:15:32,900 --> 00:15:26,220
thank you so okay thank you over on the

412
00:15:34,550 --> 00:15:32,910
side how just sort of thinking about

413
00:15:35,960 --> 00:15:34,560

most of place you're looking at in the

414
00:15:39,950 --> 00:15:35,970
next a plain sense it's all tightly

415
00:15:41,750 --> 00:15:39,960
locked so you've got one side where the

416
00:15:43,700 --> 00:15:41,760
NGO is going to be fertilized but if it

417
00:15:45,800 --> 00:15:43,710
can make it over to the night side will

418
00:15:47,810 --> 00:15:45,810
its lifetime be sort of increased

419
00:15:51,410 --> 00:15:47,820
significantly on one of the implications

420
00:15:53,360 --> 00:15:51,420
of at idea dog system I'm not sure I

421
00:15:55,880 --> 00:15:53,370
actually have no idea how Hayes's would

422
00:15:57,440 --> 00:15:55,890
work in 3d if you would be able to

423
00:15:59,470 --> 00:15:57,450
transport the necessary totalized

424
00:16:02,570 --> 00:15:59,480
components to the night side and then

425
00:16:04,070 --> 00:16:02,580
continually shield it so I don't that

426
00:16:06,200 --> 00:16:04,080
would be a 3d problem and everything

427
00:16:07,550 --> 00:16:06,210
I've thought about some in 1d that's an

428
00:16:22,010 --> 00:16:07,560
interesting question

429
00:16:23,960 --> 00:16:22,020
thank you RJ from Oxford um does after

430
00:16:25,880 --> 00:16:23,970
you if you make a lot of into if you

431
00:16:27,440 --> 00:16:25,890
have a high end to plug into a flux does

432
00:16:31,220 --> 00:16:27,450
it eventually get converted back to n2

433
00:16:33,140 --> 00:16:31,230
or as does the into oh end up like in

434
00:16:35,060 --> 00:16:33,150
the ground or something like could you

435
00:16:36,650 --> 00:16:35,070
imagine this being like a sink on on

436
00:16:38,540 --> 00:16:36,660
into and like decreasing the surface

437
00:16:42,740 --> 00:16:38,550
pressure of your planet over time or

438
00:16:44,630 --> 00:16:42,750

would it just equilibrated some value ya

439
00:16:46,550 --> 00:16:44,640
know the particle flux for these

440
00:16:47,870 --> 00:16:46,560
energetic particles are not enough to at

441
00:16:49,370 --> 00:16:47,880
least for like the modern earth you're

442
00:16:51,410 --> 00:16:49,380
not changing the background pressure and

443
00:16:52,250 --> 00:16:51,420
to by doing this it's it's relatively

444
00:17:01,990 --> 00:16:52,260
small scales

445
00:17:08,720 --> 00:17:05,960
Shami Oxford very interesting talk just

446
00:17:13,840 --> 00:17:08,730
a quick question is there also a minimum

447
00:17:17,780 --> 00:17:13,850
threshold for producing NGO with the

448
00:17:20,900 --> 00:17:17,790
nitrogen like you have to have a

449
00:17:22,520 --> 00:17:20,910
nitrogen dominating sphere right now

450
00:17:23,449 --> 00:17:22,530
that's all I've explored modeling but

451
00:17:25,970 --> 00:17:23,459
yes there would definitely be a

452
00:17:27,350 --> 00:17:25,980
dependence on that so that would be one

453
00:17:28,820 --> 00:17:27,360
thing we've one of first explorers

454
00:17:30,770 --> 00:17:28,830
what's the dependence on your nitrogen

455
00:17:32,690 --> 00:17:30,780
partial pressure and formation of n2o

456
00:17:34,100 --> 00:17:32,700
given everything else is the same but

457
00:17:41,000 --> 00:17:34,110
that yes there there would be a

458
00:17:43,680 --> 00:17:41,010
dependence if there are no additional

459
00:17:45,170 --> 00:17:43,690
questions thank you