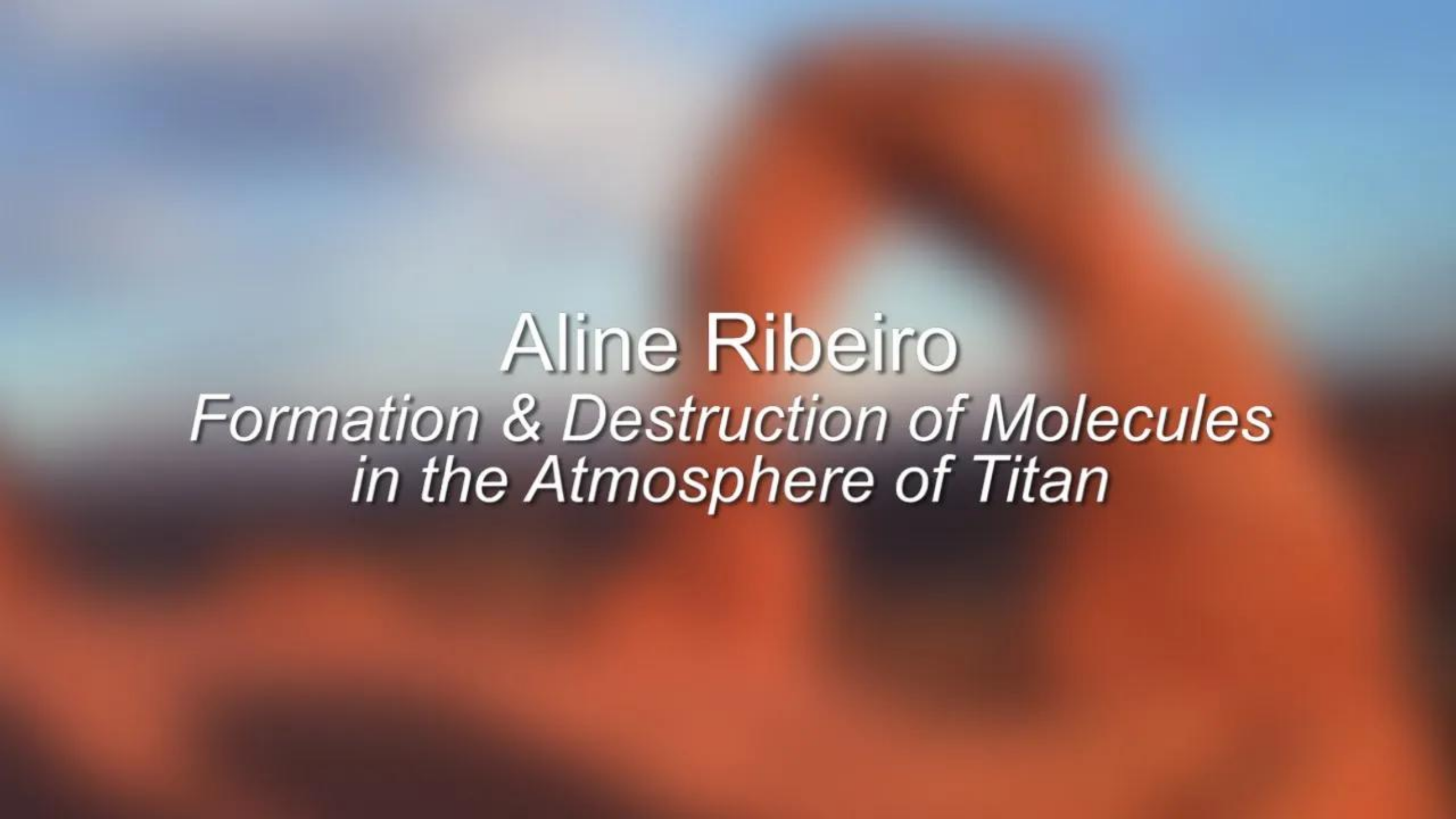
Aline Ribeiro
Formation & Destruction of Molecules
in the Atmosphere of Titan

1
00:00:00,240 --> 00:00:10,869
[Music]

2
00:00:15,829 --> 00:00:13,249
first of all I like to thank the

3
00:00:18,440 --> 00:00:15,839
opportunity to talk so this is my first

4
00:00:20,660 --> 00:00:18,450
time talking outside Brazil and maybe my

5
00:00:24,290 --> 00:00:20,670
English not very good but please forgive

6
00:00:26,630 --> 00:00:24,300
me um my name is Eleni I'm from Brazil

7
00:00:28,580 --> 00:00:26,640
and I'm finishing my master's right now

8
00:00:31,550 --> 00:00:28,590
and starting my PhD next month

9
00:00:34,430 --> 00:00:31,560
so this work I'm going to be showing you

10
00:00:37,009 --> 00:00:34,440
is my Master's work and it's about the

11
00:00:41,810 --> 00:00:37,019
information of molecules entitled

12
00:00:44,090 --> 00:00:41,820
atmosphere um first of all I like to

13
00:00:47,119 --> 00:00:44,100

start on telling you what's really

14
00:00:50,450 --> 00:00:47,129
interesting about Titan because many

15
00:00:53,149 --> 00:00:50,460
people don't know all the features so

16
00:00:58,009 --> 00:00:53,159
first of all we see the evidence of

17
00:01:01,759 --> 00:00:58,019
lakes really on the surface of the Moon

18
00:01:05,960 --> 00:01:01,769
just like the earth but um it they're

19
00:01:08,210 --> 00:01:05,970
basically formed by methane and organic

20
00:01:11,770 --> 00:01:08,220
molecules and you're gonna see that a

21
00:01:16,400 --> 00:01:11,780
little bit later as well we also see um

22
00:01:18,860 --> 00:01:16,410
volcanism just like the earth but some

23
00:01:21,890 --> 00:01:18,870
people believe there's a ocean of

24
00:01:25,640 --> 00:01:21,900
ammonia and water under the surface so

25
00:01:29,510 --> 00:01:25,650
maybe this is a way of um giving water

26
00:01:32,600 --> 00:01:29,520
to the surface after of the moon and my

27
00:01:36,530 --> 00:01:32,610
favorite part is right here that Titan

28
00:01:39,980 --> 00:01:36,540
is the only place in the solar system

29
00:01:43,370 --> 00:01:39,990
besides our planet that can is able to

30
00:01:45,410 --> 00:01:43,380
build complex and organic molecules so

31
00:01:48,050 --> 00:01:45,420
when I say complex I'm talking about

32
00:01:50,660 --> 00:01:48,060
molecules which are and which have at

33
00:01:52,730 --> 00:01:50,670
least six or more atoms and organic

34
00:01:55,490 --> 00:01:52,740
they're basically formed by carbon and

35
00:01:56,960 --> 00:01:55,500
hydrogen and we're gonna see some one

36
00:02:04,190 --> 00:01:56,970
because that's where all this nitrogen

37
00:02:08,389 --> 00:02:04,200
and oxygen so um a little bit um about

38
00:02:11,239 --> 00:02:08,399

the chemistry in Titan so just like he

39
00:02:13,509 --> 00:02:11,249
said before me we basically start

40
00:02:18,170 --> 00:02:13,519
everything with this two

41
00:02:21,649 --> 00:02:18,180
main molecules so these are nitrogen and

42
00:02:24,380 --> 00:02:21,659
methane so nitrogen is about 94 95

43
00:02:27,860 --> 00:02:24,390
percent in the atmosphere and methane is

44
00:02:30,289 --> 00:02:27,870
like basically the rest of it so this is

45
00:02:33,830 --> 00:02:30,299
where the chemistry all starts we have

46
00:02:36,970 --> 00:02:33,840
two main influences which are the solar

47
00:02:39,589 --> 00:02:36,980
radiation and basically in the u

48
00:02:43,460 --> 00:02:39,599
ultraviolet or extreme ultraviolet and

49
00:02:46,910 --> 00:02:43,470
we have another source of particles

50
00:02:50,479 --> 00:02:46,920
especially energetic particles like ions

51
00:02:54,020 --> 00:02:50,489
and electrons which come from Saturn

52
00:02:57,319 --> 00:02:54,030
because of its heavy because of its

53
00:02:59,949 --> 00:02:57,329
heavy magnetic field so there are some

54
00:03:02,119 --> 00:02:59,959
particles coming from Titans

55
00:03:05,030 --> 00:03:02,129
magnetosphere that's what we call and

56
00:03:08,180 --> 00:03:05,040
then these particles are going to be the

57
00:03:09,610 --> 00:03:08,190
second main influencer to start breaking

58
00:03:13,280 --> 00:03:09,620
these molecules and their chemistry

59
00:03:15,890 --> 00:03:13,290
starts so basically with these two main

60
00:03:18,759 --> 00:03:15,900
influences this remain Malik's are going

61
00:03:22,280 --> 00:03:18,769
to break and we're gonna start building

62
00:03:25,970 --> 00:03:22,290
more complex molecules from them so

63
00:03:28,970 --> 00:03:25,980

basically we have two main things called

64
00:03:33,559 --> 00:03:28,980
the dissociation and the ionization of

65
00:03:35,330 --> 00:03:33,569
these two molecules so this is the these

66
00:03:38,500 --> 00:03:35,340
are the two main processes that will

67
00:03:41,750 --> 00:03:38,510
create the the bigger molecules in Titan

68
00:03:45,280 --> 00:03:41,760
so just like the earth we can separate

69
00:03:48,949 --> 00:03:45,290
the the atmosphere in different layers

70
00:03:51,610 --> 00:03:48,959
but just to show you that here in the

71
00:03:57,259 --> 00:03:51,620
thermistors like the upper atmosphere

72
00:03:58,729 --> 00:03:57,269
about a thousand to 1400 um these are

73
00:04:01,819 --> 00:03:58,739
the two main models that I showed you

74
00:04:05,259 --> 00:04:01,829
methane and nitrogen so this area is

75
00:04:08,360 --> 00:04:05,269
where it out is where I'm going to start

76
00:04:10,819 --> 00:04:08,370
so when we go down the atmosphere we see

77
00:04:14,210 --> 00:04:10,829
the creation of more complex and organic

78
00:04:18,110 --> 00:04:14,220
molecules we can see here compounds made

79
00:04:21,199 --> 00:04:18,120
by carbon and hydrogen so when they're

80
00:04:23,990 --> 00:04:21,209
from they get heavier and then they go

81
00:04:26,190 --> 00:04:24,000
down the atmosphere so here in the

82
00:04:28,620 --> 00:04:26,200
lowest part this that

83
00:04:31,470 --> 00:04:28,630
the second lowest part dissatisfied we

84
00:04:34,320 --> 00:04:31,480
see something we call aerosol haze layer

85
00:04:36,930 --> 00:04:34,330
which are these organic molecules that

86
00:04:40,290 --> 00:04:36,940
start to condense and are gluten aid and

87
00:04:45,030 --> 00:04:40,300
if they form Isis and solid particles in

88
00:04:50,010 --> 00:04:45,040

the atmosphere so this which we call the

89
00:04:52,230 --> 00:04:50,020
haze layer is the reason we see when we

90
00:04:55,710 --> 00:04:52,240
observe Titan we see this very dense

91
00:04:57,810 --> 00:04:55,720
very thick kind of orange yellow

92
00:04:59,760 --> 00:04:57,820
atmosphere it's because of these

93
00:05:03,800 --> 00:04:59,770
particles these organic particles right

94
00:05:06,810 --> 00:05:03,810
here so I'm gonna talk now about my work

95
00:05:10,440 --> 00:05:06,820
this is me okay and these are my two

96
00:05:12,530 --> 00:05:10,450
advisors from from Brazil as well from

97
00:05:19,710 --> 00:05:12,540
the federal University of Rio de Janeiro

98
00:05:22,110 --> 00:05:19,720
so us three we got um we this is one of

99
00:05:24,750 --> 00:05:22,120
my advisors and she had this work with

100
00:05:28,620 --> 00:05:24,760
the southern offers where they developed

101
00:05:31,590 --> 00:05:28,630
a model to simulate atmosphere but not

102
00:05:35,300 --> 00:05:31,600
for Titan they develop it to study hot

103
00:05:38,100 --> 00:05:35,310
Jupiters so they're near my two advisors

104
00:05:41,580 --> 00:05:38,110
me a bunch of advisers we were like oh

105
00:05:43,140 --> 00:05:41,590
let's try this let's try this chemical

106
00:05:47,040 --> 00:05:43,150
model for something different for

107
00:05:49,680 --> 00:05:47,050
something that's more terrestrial maybe

108
00:05:52,110 --> 00:05:49,690
and which we know a little bit more

109
00:05:57,510 --> 00:05:52,120
because hot Jupiters are not really well

110
00:06:01,740 --> 00:05:57,520
known so we try this this chemical model

111
00:06:03,590 --> 00:06:01,750
for Titan but the problem was we can

112
00:06:06,000 --> 00:06:03,600
only work with the upper atmosphere

113
00:06:08,210 --> 00:06:06,010

that's not really a problem for us

114
00:06:11,790 --> 00:06:08,220
because as I showed you the main

115
00:06:14,970 --> 00:06:11,800
chemistry works a is really in the upper

116
00:06:18,350 --> 00:06:14,980
atmosphere in the thermosphere part but

117
00:06:22,370 --> 00:06:18,360
so basically this is why I studied

118
00:06:27,390 --> 00:06:22,380
Titans upper atmosphere so above a

119
00:06:30,540 --> 00:06:27,400
thousand kilometers and in the in the

120
00:06:33,360 --> 00:06:30,550
upper atmosphere we have these features

121
00:06:37,050 --> 00:06:33,370
is very important in my work which is

122
00:06:39,970 --> 00:06:37,060
called the atmospheric escape so some

123
00:06:42,330 --> 00:06:39,980
molecules are going to just

124
00:06:44,980 --> 00:06:42,340
escape the atmosphere as it happens here

125
00:06:48,940 --> 00:06:44,990
on the river as it happens in hot

126
00:06:52,290 --> 00:06:48,950
Jupiters and other atmospheres so this

127
00:06:55,720 --> 00:06:52,300
is how by this mechanism we're going to

128
00:07:00,100 --> 00:06:55,730
to analyze the formation of molecules in

129
00:07:03,280 --> 00:07:00,110
the atmosphere so um basically the first

130
00:07:05,050 --> 00:07:03,290
step of my work was we selected a bunch

131
00:07:07,060 --> 00:07:05,060
of species which we know from the

132
00:07:10,270 --> 00:07:07,070
literature that were in Titan's

133
00:07:12,700 --> 00:07:10,280
atmosphere so I went to a database

134
00:07:14,700 --> 00:07:12,710
called the you missed I don't know if

135
00:07:18,190 --> 00:07:14,710
any one who uses it

136
00:07:22,120 --> 00:07:18,200
it's database for interstellar molecules

137
00:07:26,500 --> 00:07:22,130
we had to adapt it to to put this

138
00:07:29,940 --> 00:07:26,510

molecules in Titan atmosphere and what

139
00:07:34,210 --> 00:07:29,950
after we selected this these compounds

140
00:07:36,430 --> 00:07:34,220
we here in the database we got all the

141
00:07:40,000 --> 00:07:36,440
reactions that these compounds go

142
00:07:42,550 --> 00:07:40,010
through so here for example this is a

143
00:07:47,590 --> 00:07:42,560
methane which is one of the main

144
00:07:49,450 --> 00:07:47,600
products of reactions in Titan so here

145
00:07:52,440 --> 00:07:49,460
in the database we have all the

146
00:07:55,090 --> 00:07:52,450
reactions that will happen with a thing

147
00:07:57,340 --> 00:07:55,100
for information and for destruction as

148
00:08:00,550 --> 00:07:57,350
well so we got all these reactions we

149
00:08:04,060 --> 00:08:00,560
got all day out there constants and we

150
00:08:06,670 --> 00:08:04,070
put it on the equations and this is um

151
00:08:09,640 --> 00:08:06,680
this is basically the word so the last

152
00:08:12,070 --> 00:08:09,650
part is we put all that reaction in

153
00:08:15,070 --> 00:08:12,080
equations in continuation continuity

154
00:08:18,490 --> 00:08:15,080
equations and we use the program to

155
00:08:20,800 --> 00:08:18,500
solve that so basically the continuity

156
00:08:23,560 --> 00:08:20,810
equation for the molecules is basically

157
00:08:25,870 --> 00:08:23,570
this one which is one molecule so we

158
00:08:28,870 --> 00:08:25,880
have one separate equation for each

159
00:08:32,110 --> 00:08:28,880
molecule we have like a 100 molecules or

160
00:08:34,690 --> 00:08:32,120
something so the reactions go right here

161
00:08:38,860 --> 00:08:34,700
this is a reactions product right and

162
00:08:42,190 --> 00:08:38,870
this is the loss rate but our um our

163
00:08:44,590 --> 00:08:42,200

mother our mother was um only

164
00:08:47,140 --> 00:08:44,600
dimensional and stationary so we didn't

165
00:08:51,630 --> 00:08:47,150
considered time so this goes to zero

166
00:08:54,030 --> 00:08:51,640
actually and then two to

167
00:08:57,410 --> 00:08:54,040
but this molecules in my work I had to

168
00:09:00,079 --> 00:08:57,420
put some previous profiles for the main

169
00:09:02,699 --> 00:09:00,089
molecules so I put the profiles for

170
00:09:06,210 --> 00:09:02,709
nitrogen and for methane

171
00:09:08,670 --> 00:09:06,220
I also use the profile for hydrogen

172
00:09:11,009 --> 00:09:08,680
molecular hydrogen because it's the main

173
00:09:12,990 --> 00:09:11,019
molecule that's going to escape the

174
00:09:14,100 --> 00:09:13,000
atmosphere and sit for working with

175
00:09:17,730 --> 00:09:14,110
upper atmosphere

176
00:09:22,590 --> 00:09:17,740
I used hydrogen as well these two

177
00:09:24,720 --> 00:09:22,600
profiles are from this work in 2008 so

178
00:09:27,780 --> 00:09:24,730
this is our result I'm gonna show you

179
00:09:29,449 --> 00:09:27,790
the main marks we found basically these

180
00:09:33,449 --> 00:09:29,459
three main molecules which are called

181
00:09:37,019 --> 00:09:33,459
acetylene ethylene anything are the

182
00:09:39,150 --> 00:09:37,029
three main products my reactions in

183
00:09:42,060 --> 00:09:39,160
Titan's atmosphere so this is their

184
00:09:45,180 --> 00:09:42,070
abundances and this is the altitude it's

185
00:09:48,750 --> 00:09:45,190
in the horizontal but you pretend like

186
00:09:50,850 --> 00:09:48,760
the Titan is here and the altitude is

187
00:09:53,730 --> 00:09:50,860
going that way so these are the three

188
00:09:57,530 --> 00:09:53,740

and this remaining molecules we found by

189
00:09:59,720 --> 00:09:57,540
that products by that reaction sorry and

190
00:10:02,750 --> 00:09:59,730
these are basically the hyper

191
00:10:07,139 --> 00:10:02,760
hydrocarbon molecules so we also find

192
00:10:09,560 --> 00:10:07,149
molecules with oxygen but I didn't

193
00:10:12,780 --> 00:10:09,570
mention oxygen before because it's not

194
00:10:16,319 --> 00:10:12,790
it's initially not in Titan's atmosphere

195
00:10:19,860 --> 00:10:16,329
it actually comes from Enceladus so it

196
00:10:22,769 --> 00:10:19,870
has a inflow of oxygen especially

197
00:10:26,759 --> 00:10:22,779
especially oxygen ions in the atmosphere

198
00:10:31,040 --> 00:10:26,769
so we also we can also see some some

199
00:10:35,579 --> 00:10:31,050
oxygen bearing molecules here and we see

200
00:10:38,579 --> 00:10:35,589
co which is basically um I guess the

201
00:10:41,759 --> 00:10:38,589
fourth may molecule in in the atmosphere

202
00:10:43,949 --> 00:10:41,769
and it's really stable because its

203
00:10:46,170 --> 00:10:43,959
contents temperature is really cold so

204
00:10:49,110 --> 00:10:46,180
it basically doesn't condense in fact in

205
00:10:51,840 --> 00:10:49,120
the atmosphere and the best part for me

206
00:10:53,699 --> 00:10:51,850
is that we also found nitrogen bearing

207
00:10:56,550 --> 00:10:53,709
molecules which is important for life

208
00:10:58,620 --> 00:10:56,560
and stuff so this is the main molecule

209
00:11:01,199 --> 00:10:58,630
we found which is hydrogen cyanide is

210
00:11:04,830 --> 00:11:01,209
one of the basic molecules we can find

211
00:11:08,310 --> 00:11:04,840
in the interstellar medium and we're

212
00:11:11,250 --> 00:11:08,320
found different molecules as well so we

213
00:11:13,620 --> 00:11:11,260

found some we found some complex

214
00:11:15,930 --> 00:11:13,630
molecules which is great for us because

215
00:11:18,870 --> 00:11:15,940
you can see this like anywhere else in

216
00:11:21,420 --> 00:11:18,880
the solar system so we found this one

217
00:11:25,530 --> 00:11:21,430
for examples for pure nitrile we found

218
00:11:29,400 --> 00:11:25,540
Osetra nitrile and this CN was settling

219
00:11:32,880 --> 00:11:29,410
to me and yes that's a pretty great

220
00:11:35,460 --> 00:11:32,890
result for us um another thing we did in

221
00:11:37,500 --> 00:11:35,470
our work was try to show the difference

222
00:11:39,510 --> 00:11:37,510
between considering the energetic

223
00:11:42,570 --> 00:11:39,520
particles that come from Saturn's

224
00:11:45,380 --> 00:11:42,580
magnetosphere so we tried to run the

225
00:11:50,870 --> 00:11:45,390
model with and without this influence of

226
00:11:54,330 --> 00:11:50,880
energetic particles so I show you here

227
00:11:57,960 --> 00:11:54,340
some molecules and some ions and we can

228
00:12:00,750 --> 00:11:57,970
see if um these these direct ones are

229
00:12:03,200 --> 00:12:00,760
without the magnetospheric influence and

230
00:12:06,590 --> 00:12:03,210
the solid ones are considering the

231
00:12:09,690 --> 00:12:06,600
magnetospheric influence so we basically

232
00:12:12,540 --> 00:12:09,700
discovered that this influence is

233
00:12:15,090 --> 00:12:12,550
especially in small molecules and ions

234
00:12:18,590 --> 00:12:15,100
so the biggest molecules we found they

235
00:12:22,260 --> 00:12:18,600
were not affected by this this

236
00:12:24,810 --> 00:12:22,270
magnetospheric energetic particles so

237
00:12:25,440 --> 00:12:24,820
basically this comes this concludes my

238
00:12:29,640 --> 00:12:25,450

work

239
00:12:33,000 --> 00:12:29,650
we found the abundances the simulated

240
00:12:37,950 --> 00:12:33,010
abundances for compounds with carbon

241
00:12:40,890 --> 00:12:37,960
hydrogen oxygen and nitrogen we got um a

242
00:12:44,370 --> 00:12:40,900
pretty good simulation considering we

243
00:12:46,860 --> 00:12:44,380
didn't consider other mechanisms like

244
00:12:48,900 --> 00:12:46,870
the haze formation which is lower in the

245
00:12:51,650 --> 00:12:48,910
atmosphere we just consider the upper

246
00:12:54,960 --> 00:12:51,660
atmosphere for this work and we also

247
00:12:58,680 --> 00:12:54,970
found some visible effects of the

248
00:13:01,470 --> 00:12:58,690
influence of Saturn's magnetosphere so

249
00:13:03,900 --> 00:13:01,480
for the future what I want to do with

250
00:13:06,060 --> 00:13:03,910
this work maybe not me but some other

251
00:13:09,900 --> 00:13:06,070
student we want to try to include more

252
00:13:12,360 --> 00:13:09,910
molecules in this model especially maybe

253
00:13:14,700 --> 00:13:12,370
sulfur and phosphorus molecules which

254
00:13:18,720 --> 00:13:14,710
are also really important if we want to

255
00:13:22,890 --> 00:13:18,730
find life somewhere we want to include

256
00:13:25,890 --> 00:13:22,900
the Collins and his formations so we

257
00:13:27,480 --> 00:13:25,900
want to to run the model for all the

258
00:13:31,410 --> 00:13:27,490
atmosphere not just the upper atmosphere

259
00:13:33,560 --> 00:13:31,420
and we want to try to do some lab

260
00:13:36,390 --> 00:13:33,570
experiments trying to simulate that

261
00:13:39,390 --> 00:13:36,400
really in a chamber with all the

262
00:13:41,130 --> 00:13:39,400
molecules we found and see if that could

263
00:13:44,850 --> 00:13:41,140

develop anything else or anything

264
00:13:49,280 --> 00:13:44,860
different we from we found in the

265
00:13:53,490 --> 00:13:49,290
computer in the computer computer model

266
00:13:55,650 --> 00:13:53,500
this is basically my wor solo I'm open

267
00:14:06,890 --> 00:13:55,660
to any questions now if you have them

268
00:14:09,540 --> 00:14:06,900
thank you thank you very much for that

269
00:14:10,710 --> 00:14:09,550
thank you very much for the talk we have

270
00:14:21,560 --> 00:14:10,720
any questions we got time for maybe one

271
00:14:24,840 --> 00:14:21,570
or two so the question is about

272
00:14:32,700 --> 00:14:24,850
methodology from your ears to your

273
00:14:36,150 --> 00:14:32,710
modeling okay so we when we had to put

274
00:14:39,450 --> 00:14:36,160
each reaction in this continuous

275
00:14:43,430 --> 00:14:39,460
irritation equation we have for example

276
00:14:48,890 --> 00:14:43,440
from the database we have the reactions

277
00:14:52,080 --> 00:14:48,900
constants constants and then we put on

278
00:14:57,900 --> 00:14:52,090
we put on this continuity equation but

279
00:15:02,280 --> 00:14:57,910
we adhere factor to to consider the

280
00:15:04,560 --> 00:15:02,290
folks from system and the flux from the

281
00:15:06,930 --> 00:15:04,570
energetic particles no sorry it's

282
00:15:10,230 --> 00:15:06,940
actually here so we have here the flux

283
00:15:14,910 --> 00:15:10,240
factor then we add another constant here

284
00:15:19,470 --> 00:15:14,920
to to consider this influence so we did

285
00:15:22,380 --> 00:15:19,480
that for two different things for the UV

286
00:15:26,280 --> 00:15:22,390
sunlight and then for the Saturn

287
00:15:28,590 --> 00:15:26,290
energetic particles I just um I went

288
00:15:41,370 --> 00:15:28,600

through this part because it's it's the

289
00:15:41,380 --> 00:15:51,830
[Music]

290
00:16:04,500 --> 00:16:01,800
with it with it we actually um yes we're

291
00:16:06,960 --> 00:16:04,510
considered elected to it all uniform but

292
00:16:11,190 --> 00:16:06,970
we actually know in fact that Murphy we

293
00:16:13,530 --> 00:16:11,200
have wind and circulation of convection

294
00:16:15,780 --> 00:16:13,540
circulation this is something else we

295
00:16:39,210 --> 00:16:15,790
could put in the model but it's a really

296
00:16:42,900 --> 00:16:39,220
difficult thing to do so since we did

297
00:16:45,380 --> 00:16:42,910
consider but is here in the upper

298
00:16:52,940 --> 00:16:45,390
atmosphere they're not really in

299
00:17:02,010 --> 00:16:54,800
like

300
00:17:10,290 --> 00:17:05,130
yeah we considered they're all going to

301
00:17:14,010 --> 00:17:10,300
- they're going to be uniform basically

302
00:17:16,189 --> 00:17:14,020
as I said in the latitude and everywhere

303
00:17:20,429 --> 00:17:16,199
else but we just considered a

304
00:17:22,010 --> 00:17:20,439
one-dimensional model so this is we

305
00:17:25,020 --> 00:17:22,020
actually work with the altitude

306
00:17:27,929 --> 00:17:25,030
dimension I'm sorry to put it in the

307
00:17:30,090 --> 00:17:27,939
horizontally this is not very this is

308
00:17:32,910 --> 00:17:30,100
very weird for me but the model works

309
00:17:34,890 --> 00:17:32,920
like this so we only considered this

310
00:17:36,330 --> 00:17:34,900
direction the other directions were not