2017 Astrobiology Graduate Conference

Charlottesville, VA

1
00:00:00,790 --> 00:00:07,960
[Music]

2
00:00:12,049 --> 00:00:10,490
hey everybody my name is Xander I'm from

3
00:00:13,129 --> 00:00:12,059
New Mexico State University I'm here to

4
00:00:15,289 --> 00:00:13,139
talk to you today about

5
00:00:17,990 --> 00:00:15,299
Titan's atmosphere and some work I've

6
00:00:23,330 --> 00:00:18,000
been doing using some public Alma data

7
00:00:25,160 --> 00:00:23,340
so as we just saw in Aleks talk Titan is

8
00:00:27,200 --> 00:00:25,170
a pretty cool place it's the second

9
00:00:29,720 --> 00:00:27,210
largest moon in the solar system overall

10
00:00:32,150 --> 00:00:29,730
and it's substantial atmosphere haze

11
00:00:34,400 --> 00:00:32,160
methane and other ice clouds as well as

12
00:00:35,600 --> 00:00:34,410
all the surface liquid features some

13
00:00:37,850 --> 00:00:35,610

voids are temporary and some of which

14
00:00:39,619 --> 00:00:37,860
are more permanent and the subsurface

15
00:00:41,510 --> 00:00:39,629
ocean finally make it a really

16
00:00:42,860 --> 00:00:41,520
interesting place to study for assert

17
00:00:46,639 --> 00:00:42,870
biology as part of this kind of new

18
00:00:51,439 --> 00:00:46,649
emerging ocean worlds project that NASA

19
00:00:54,529 --> 00:00:51,449
has been undertaking so most of this was

20
00:00:55,970 --> 00:00:54,539
discovered as we just saw by the Cassini

21
00:00:58,310 --> 00:00:55,980
mission which really blew the door wide

22
00:00:59,420 --> 00:00:58,320
open for Titan and also Saturn studies

23
00:01:02,479 --> 00:00:59,430
but we don't really care about setter

24
00:01:05,000 --> 00:01:02,489
and Enceladus as well so Cassini did a

25
00:01:07,399 --> 00:01:05,010
lot of great so this study so it's just

26
00:01:10,760 --> 00:01:07,409
been a wealth of data coming in since

27
00:01:13,100 --> 00:01:10,770
2004 from the Cassini mission and part

28
00:01:15,649 --> 00:01:13,110
of that was the Huygens probe descent as

29
00:01:18,200 --> 00:01:15,659
we also saw so in January of 2005

30
00:01:21,649 --> 00:01:18,210
Wiggins parachuted down into Titan's

31
00:01:23,060 --> 00:01:21,659
atmosphere and as we went through for

32
00:01:25,940 --> 00:01:23,070
the first time we were able to finally

33
00:01:27,260 --> 00:01:25,950
get below this haze layer on Titan which

34
00:01:29,899 --> 00:01:27,270
previously had just been kind of this

35
00:01:32,300 --> 00:01:29,909
big orange ball next to Saturn and we're

36
00:01:34,370 --> 00:01:32,310
really able to see all of these really

37
00:01:36,770 --> 00:01:34,380
cool surface features so there's valleys

38
00:01:39,319 --> 00:01:36,780

and mountains and dunes similar to those

39
00:01:40,609 --> 00:01:39,329
on earth flew of your features and all

40
00:01:43,010 --> 00:01:40,619
kinds of stuff and as you go down

41
00:01:46,069 --> 00:01:43,020
through this haze layer for the first

42
00:01:49,999 --> 00:01:46,079
time ever you're able to find the fabled

43
00:01:51,830 --> 00:01:50,009
city of Los Angeles and so if you never

44
00:01:52,310 --> 00:01:51,840
see a Titan top 4 that's the obligatory

45
00:01:54,170 --> 00:01:52,320
joke

46
00:01:57,910 --> 00:01:54,180
thank you very much stealing it so

47
00:02:00,319 --> 00:01:57,920
anyway a lot of these products of the

48
00:02:02,209 --> 00:02:00,329
chemistry in Titan's atmosphere come

49
00:02:04,880 --> 00:02:02,219
from the dissociation of methane and

50
00:02:07,429 --> 00:02:04,890
molecular nitrogen so as we just covered

51
00:02:08,990 --> 00:02:07,439
it's mostly molecular nitrogen molecular

52
00:02:10,339 --> 00:02:09,000
nitrogen a little bit of methane and

53
00:02:11,960 --> 00:02:10,349
these things get broken down by

54
00:02:13,700 --> 00:02:11,970
energetic particles as well as photons

55
00:02:15,800 --> 00:02:13,710
in the upper atmosphere

56
00:02:17,960 --> 00:02:15,810
and react with ions and other products

57
00:02:20,420 --> 00:02:17,970
from Saturn's my newest fear as well as

58
00:02:22,280 --> 00:02:20,430
in syllabus raining in with a little bit

59
00:02:24,440 --> 00:02:22,290
of oxygen to create all kinds of cool

60
00:02:27,080 --> 00:02:24,450
stuff so there are polycyclic aromatic

61
00:02:29,060 --> 00:02:27,090
hydrocarbons or pause that get formed in

62
00:02:31,700 --> 00:02:29,070
these larger particles kind of

63
00:02:33,530 --> 00:02:31,710

accumulate in the lower atmosphere and

64
00:02:35,600 --> 00:02:33,540
some condense out and some kind of form

65
00:02:37,160 --> 00:02:35,610
into these larger aerosols or haze

66
00:02:38,690 --> 00:02:37,170
products and this is mostly what I'm

67
00:02:43,580 --> 00:02:38,700
going to be talking about throughout

68
00:02:45,680 --> 00:02:43,590
this talk and Cassini particularly in

69
00:02:47,390 --> 00:02:45,690
the infrared was a great way to study

70
00:02:48,890 --> 00:02:47,400
this so a lot of new molecules were

71
00:02:51,140 --> 00:02:48,900
detected in the atmosphere here an

72
00:02:53,660 --> 00:02:51,150
example of some Cassini composite

73
00:02:56,420 --> 00:02:53,670
infrared spectra from the Sirius

74
00:02:59,840 --> 00:02:56,430
instrument so both above and below are

75
00:03:03,230 --> 00:02:59,850
from Sears at different wave numbers or

76
00:03:05,840 --> 00:03:03,240
if you're into wave numbers probably not

77
00:03:07,910 --> 00:03:05,850
or if you're into microns and so there's

78
00:03:10,190 --> 00:03:07,920
you know kind of ethane and methane

79
00:03:12,740 --> 00:03:10,200
bands and acetylene all kinds of cool

80
00:03:15,320 --> 00:03:12,750
hydrocarbons that get closer to here so

81
00:03:16,850 --> 00:03:15,330
it's just a really amazing data set to

82
00:03:18,740 --> 00:03:16,860
both discover new molecules and also

83
00:03:20,360 --> 00:03:18,750
kind of see how these things change in

84
00:03:22,370 --> 00:03:20,370
Titan's atmosphere as we go from

85
00:03:25,580 --> 00:03:22,380
different regions because Cassini has

86
00:03:28,670 --> 00:03:25,590
very good latitudinal resolution so if

87
00:03:31,220 --> 00:03:28,680
you're more into the chemistry of this

88
00:03:33,860 --> 00:03:31,230

here's kind of a diagram and with the

89
00:03:36,500 --> 00:03:33,870
advent of Cassini comes a wealth of

90
00:03:39,470 --> 00:03:36,510
these photochemical models which are

91
00:03:41,480 --> 00:03:39,480
able to try to predict the products of

92
00:03:42,920 --> 00:03:41,490
this atmosphere see how abundant they

93
00:03:45,740 --> 00:03:42,930
are and kind of see how far we can push

94
00:03:47,900 --> 00:03:45,750
the rich organic chemistry of Titan's

95
00:03:50,390 --> 00:03:47,910
atmosphere and so on the left is mostly

96
00:03:51,980 --> 00:03:50,400
the products of methane chemistry which

97
00:03:53,510 --> 00:03:51,990
are the hydrocarbons and on the right

98
00:03:55,250 --> 00:03:53,520
are the nitrile so you don't have to get

99
00:03:57,740 --> 00:03:55,260
too invested into this but a few of them

100
00:04:01,130 --> 00:03:57,750
I may be talking about today are HCN

101
00:04:03,920 --> 00:04:01,140
methyl saline cyano acetylene and these

102
00:04:05,900 --> 00:04:03,930
were seen by Cassini previously the

103
00:04:08,090 --> 00:04:05,910
submillimetre we had detected cu nitrile

104
00:04:11,330 --> 00:04:08,100
or methyl acetylene and i'll be talking

105
00:04:13,040 --> 00:04:11,340
about that as well as well as a few new

106
00:04:14,660 --> 00:04:13,050
products that have been detected

107
00:04:16,250 --> 00:04:14,670
recently and these are acrylic and

108
00:04:19,310 --> 00:04:16,260
propio nitrile I may also call these

109
00:04:20,390 --> 00:04:19,320
vinyl sign methyl cyanide because as it

110
00:04:23,680 --> 00:04:20,400
bounced around I don't know anything

111
00:04:26,890 --> 00:04:23,690
about chemistry so enjoy that um anyway

112
00:04:29,170 --> 00:04:26,900
these are really cool products but

113
00:04:30,460 --> 00:04:29,180

and the later part of this year we're

114
00:04:33,100 --> 00:04:30,470
actually going to be losing all this

115
00:04:35,110 --> 00:04:33,110
coverage from Cassini and that's going

116
00:04:36,129 --> 00:04:35,120
to be really unfortunate but Cassini is

117
00:04:38,469 --> 00:04:36,139
going through this really cool process

118
00:04:40,779 --> 00:04:38,479
right now where it goes between the

119
00:04:42,520 --> 00:04:40,789
planet and the inner rings which is

120
00:04:45,640 --> 00:04:42,530
somewhere we've never been before with

121
00:04:47,529 --> 00:04:45,650
Voyager or anything else and it's just

122
00:04:49,719 --> 00:04:47,539
going to be a fantastic thing and this

123
00:04:52,240 --> 00:04:49,729
is called the grand finale of Cassini so

124
00:04:55,180 --> 00:04:52,250
look down for that and we can only wish

125
00:04:58,120 --> 00:04:55,190
our own finales were as grand but until

126
00:05:02,469 --> 00:04:58,130
then we can use Alma to study Titan so

127
00:05:04,390 --> 00:05:02,479
Alma is this large radio telescope it's

128
00:05:06,340 --> 00:05:04,400
a nada comma Desert of Chile you've

129
00:05:07,750 --> 00:05:06,350
probably seen this picture already in

130
00:05:09,310 --> 00:05:07,760
other slides talking about almost so

131
00:05:11,230 --> 00:05:09,320
there were some great introductions this

132
00:05:12,640 --> 00:05:11,240
is actually the only photograph of Alma

133
00:05:14,740 --> 00:05:12,650
ever taken which is what you've seen

134
00:05:19,450 --> 00:05:14,750
this picture of four times that's not

135
00:05:21,550 --> 00:05:19,460
your ISO so Alma actually uses Titan as

136
00:05:22,900 --> 00:05:21,560
a calibration object pretty often so

137
00:05:25,150 --> 00:05:22,910
there are other people talking

138
00:05:28,180 --> 00:05:25,160

previously about using Alma to study

139
00:05:29,110 --> 00:05:28,190
protoplanetary discs and radio jets and

140
00:05:31,510 --> 00:05:29,120
galaxies and all kinds of other cool

141
00:05:34,930 --> 00:05:31,520
stuff so often when that happens Titan

142
00:05:37,060 --> 00:05:34,940
is taken as kind of a image switched off

143
00:05:38,969 --> 00:05:37,070
from whatever other target you're using

144
00:05:41,260 --> 00:05:38,979
to calibrate their flux measurements

145
00:05:44,050 --> 00:05:41,270
those go through the pipeline and then

146
00:05:46,629 --> 00:05:44,060
the Titan gets kind of ejected out into

147
00:05:47,740 --> 00:05:46,639
the archive where you two can use it if

148
00:05:50,620 --> 00:05:47,750
you want to scoop my dissertation

149
00:05:53,409 --> 00:05:50,630
projects so it is there for the taking

150
00:05:57,430 --> 00:05:53,419
don't do that though so here are some of

151
00:05:59,770 --> 00:05:57,440
the data from the Alma telescope some of

152
00:06:01,480 --> 00:05:59,780
these public data are only like three

153
00:06:03,159 --> 00:06:01,490
minute long exposures that very short

154
00:06:05,260 --> 00:06:03,169
but even within that we're able to get

155
00:06:06,730 --> 00:06:05,270
out these really cool spectra that

156
00:06:10,510 --> 00:06:06,740
showed tons of interesting stuff so

157
00:06:13,510 --> 00:06:10,520
there's some methyl acetylene bands here

158
00:06:16,600 --> 00:06:13,520
and then these were new detection of a

159
00:06:18,159 --> 00:06:16,610
couple of molecules so we have a FL

160
00:06:19,629 --> 00:06:18,169
cyanide line here that's not the only

161
00:06:21,490 --> 00:06:19,639
one that day so there's plenty more else

162
00:06:23,230 --> 00:06:21,500
inés everywhere in the homo data which

163
00:06:24,969 --> 00:06:23,240

is exciting and also there was a

164
00:06:27,879 --> 00:06:24,979
internet gatherer who discovered this

165
00:06:30,760 --> 00:06:27,889
vinyl cyanide or acrylonitrile on the

166
00:06:32,260 --> 00:06:30,770
wings of this carbon monoxide line here

167
00:06:34,089 --> 00:06:32,270
and so that was kind of hard to find but

168
00:06:35,950 --> 00:06:34,099
there's been a follow-up study about

169
00:06:38,110 --> 00:06:35,960
this and it's definitely confirmed and

170
00:06:39,279 --> 00:06:38,120
these two molecules in particular are

171
00:06:40,450 --> 00:06:39,289
pretty interesting because they were

172
00:06:44,439 --> 00:06:40,460
studied

173
00:06:47,770 --> 00:06:44,449
only as potential molecules which may

174
00:06:50,260 --> 00:06:47,780
form structures within Titans kind of

175
00:06:52,450 --> 00:06:50,270
surface liquid features these eutectics

176
00:06:54,820 --> 00:06:52,460
of methane and ethane and very cold

177
00:06:57,820 --> 00:06:54,830
temperatures turns out that molecules

178
00:07:00,879 --> 00:06:57,830
like acrylonitrile may actually be able

179
00:07:04,510 --> 00:07:00,889
to form these kind of liposome analogues

180
00:07:06,999 --> 00:07:04,520
but in Titans cold atmosphere and our

181
00:07:09,100 --> 00:07:07,009
sorry cold surface chemistry and because

182
00:07:10,480 --> 00:07:09,110
these are kind of polar nitrogen

183
00:07:12,850 --> 00:07:10,490
molecules they've been dubbed

184
00:07:16,600 --> 00:07:12,860
zoda's ohms and I don't really know too

185
00:07:20,200 --> 00:07:16,610
much about liposome zones and whatever

186
00:07:22,839 --> 00:07:20,210
this sunflower thing is but this is an

187
00:07:25,330 --> 00:07:22,849
interesting way to kind of kind of try

188
00:07:26,499 --> 00:07:25,340

to tie the atmosphere chemistry of Titan

189
00:07:28,330 --> 00:07:26,509
together with any kind of surface

190
00:07:30,999 --> 00:07:28,340
processes and look for interesting

191
00:07:32,649 --> 00:07:31,009
astrobiological a significant things

192
00:07:34,060 --> 00:07:32,659
there so here are the list of some of

193
00:07:36,370 --> 00:07:34,070
the other molecules that have been

194
00:07:38,920 --> 00:07:36,380
studied and we found all of these with

195
00:07:41,499 --> 00:07:38,930
either Cassini or OMA as a now with the

196
00:07:43,570 --> 00:07:41,509
exception of a few here and recently I

197
00:07:46,420 --> 00:07:43,580
put in a cycle v proposal to target

198
00:07:48,879 --> 00:07:46,430
specifically cyano Halloween HD 5n and

199
00:07:50,439 --> 00:07:48,889
then also a type of this primary nitrile

200
00:07:52,390 --> 00:07:50,449
which is propyl cyanide which we found

201
00:07:54,760 --> 00:07:52,400
in the interstellar medium so far so

202
00:07:57,399 --> 00:07:54,770
fingers crossed for that to come in and

203
00:07:59,140 --> 00:07:57,409
we'll see what we can find in the

204
00:08:01,529 --> 00:07:59,150
meantime we can take a lot of this Alma

205
00:08:05,730 --> 00:08:01,539
data and make these kind of cool maps of

206
00:08:08,649 --> 00:08:05,740
stacked flux and you can see even with

207
00:08:11,499 --> 00:08:08,659
relatively large spatial resolution

208
00:08:13,180 --> 00:08:11,509
compared to Titan so it's not really

209
00:08:16,240 --> 00:08:13,190
resolved you can see these kind of

210
00:08:18,850 --> 00:08:16,250
lopsided asymmetries within hemispheric

211
00:08:21,040 --> 00:08:18,860
constituents so there's a fo cyanide and

212
00:08:23,589 --> 00:08:21,050
vinyl sign up on the top and then a c3

213
00:08:25,659 --> 00:08:23,599

an and methyl is sewing here and of

214
00:08:27,850 --> 00:08:25,669
these three methyl acetylene seems to be

215
00:08:29,740 --> 00:08:27,860
concentrated in the north and the rest

216
00:08:30,550 --> 00:08:29,750
of them are concentrated south this is

217
00:08:32,230 --> 00:08:30,560
from 2015

218
00:08:33,639 --> 00:08:32,240
when Titan transitions into the northern

219
00:08:35,920 --> 00:08:33,649
summer so basically what's happening

220
00:08:38,440 --> 00:08:35,930
here is they're saying the use three

221
00:08:41,050 --> 00:08:38,450
products are being kind of condensed

222
00:08:43,000 --> 00:08:41,060
down on the winter or southern

223
00:08:44,980 --> 00:08:43,010
hemisphere of Titan with the exception

224
00:08:47,019 --> 00:08:44,990
of methyl acetylene which seems to be

225
00:08:49,090 --> 00:08:47,029
more resilient to photochemical

226
00:08:51,430 --> 00:08:49,100
destruction its chemical lifetime in the

227
00:08:52,720 --> 00:08:51,440
atmosphere is longer and this is a

228
00:08:53,769 --> 00:08:52,730
really interesting thing that we can see

229
00:08:56,679 --> 00:08:53,779
just from these maps

230
00:08:58,569 --> 00:08:56,689
what I'd like to do in addition to

231
00:09:00,489 --> 00:08:58,579
trying to find new molecular species is

232
00:09:03,400 --> 00:09:00,499
to try to actually really pull out very

233
00:09:05,170 --> 00:09:03,410
distinct spatially resolved abundances

234
00:09:07,090 --> 00:09:05,180
and temperatures of these molecules in

235
00:09:09,040 --> 00:09:07,100
the atmosphere and see if we can measure

236
00:09:11,530 --> 00:09:09,050
these very oceans over time and with

237
00:09:13,449 --> 00:09:11,540
Alma coming online in 2012 we have this

238
00:09:15,670 --> 00:09:13,459

kind of little overlap region where we

239
00:09:18,189 --> 00:09:15,680
can use all my data and Ksenia together

240
00:09:20,519 --> 00:09:18,199
to see some of the seasonal transitions

241
00:09:23,199 --> 00:09:20,529
as Titan goes into its northern summer

242
00:09:25,769 --> 00:09:23,209
so I do this with radiative transfer

243
00:09:28,829 --> 00:09:25,779
modeling the program I use is called the

244
00:09:32,759 --> 00:09:28,839
nonlinear optimal estimator for

245
00:09:35,829 --> 00:09:32,769
multivariate spectral analysis or

246
00:09:38,650 --> 00:09:35,839
nemesis I didn't make up that name but

247
00:09:40,329 --> 00:09:38,660
there it it so nemesis allows you to

248
00:09:42,519 --> 00:09:40,339
build a model atmosphere of whatever

249
00:09:43,780 --> 00:09:42,529
planet you're working on it's you can

250
00:09:47,019 --> 00:09:43,790
use it for a variety of different things

251
00:09:49,299 --> 00:09:47,029
and construct this kind of temperature

252
00:09:50,679 --> 00:09:49,309
pressure and abundance diagram as well

253
00:09:52,449 --> 00:09:50,689
as all kinds of other knobs you can get

254
00:09:54,519 --> 00:09:52,459
and make synthetic spectra out and

255
00:09:56,679 --> 00:09:54,529
you're able to compare that to these

256
00:09:59,290 --> 00:09:56,689
data in this kind of a goodness to fit

257
00:10:01,269 --> 00:09:59,300
we sky squared method it's iterative and

258
00:10:03,160 --> 00:10:01,279
it's very powerful and with the addition

259
00:10:04,840 --> 00:10:03,170
of Cassini measurements which are super

260
00:10:06,610 --> 00:10:04,850
well constrained particularly those for

261
00:10:08,590 --> 00:10:06,620
Wiggins which actually has been there

262
00:10:10,689 --> 00:10:08,600
this allows our models to be fairly

263
00:10:12,759 --> 00:10:10,699

robust and therefore you can say that

264
00:10:16,679 --> 00:10:12,769
any variation in spectra that you find

265
00:10:18,549 --> 00:10:16,689
are due to abundance or temperature

266
00:10:20,949 --> 00:10:18,559
variations that are pretty minor

267
00:10:21,910 --> 00:10:20,959
compared to the Cassini measurements so

268
00:10:24,220 --> 00:10:21,920
what I've been doing is finding data

269
00:10:26,410 --> 00:10:24,230
sets that are spatially resolved to

270
00:10:28,119 --> 00:10:26,420
Titan as in the the beam size the

271
00:10:29,530 --> 00:10:28,129
resolution elements smaller than Titans

272
00:10:31,840 --> 00:10:29,540
disk usually we run a third of it and

273
00:10:33,939 --> 00:10:31,850
you can kind of probe these different

274
00:10:37,119 --> 00:10:33,949
regions these kind of I'll be calling

275
00:10:39,699 --> 00:10:37,129
them South Center and North for the rest

276
00:10:42,040 --> 00:10:39,709
of this for lack of a better way of

277
00:10:43,660 --> 00:10:42,050
doing it and this allows you to kind of

278
00:10:45,549 --> 00:10:43,670
pull out different measurements and see

279
00:10:47,530 --> 00:10:45,559
if you can actually see these variations

280
00:10:49,889 --> 00:10:47,540
across Titans discs so as an example

281
00:10:51,610 --> 00:10:49,899
here are a bunch of carbon monoxide

282
00:10:53,290 --> 00:10:51,620
spectra and you'll have to look at these

283
00:10:55,900 --> 00:10:53,300
too hard because they all look pretty

284
00:10:58,629 --> 00:10:55,910
similar but there's a data from 2012

285
00:11:00,699 --> 00:10:58,639
2014 and 2015 that are all spatially

286
00:11:03,340 --> 00:11:00,709
resolved and the column on the left is

287
00:11:05,340 --> 00:11:03,350
the southern and then Center and then

288
00:11:07,480 --> 00:11:05,350

north and they look pretty much the same

289
00:11:09,310 --> 00:11:07,490
the cool thing that you can know

290
00:11:11,460 --> 00:11:09,320
here's the dais in black and the models

291
00:11:13,449 --> 00:11:11,470
are in red so particularly for the

292
00:11:15,220 --> 00:11:13,459
2014-2015 data we're doing a very good

293
00:11:17,800 --> 00:11:15,230
job of thinning these lines chi-squared

294
00:11:19,780 --> 00:11:17,810
is like 1 and also another thing to note

295
00:11:21,760 --> 00:11:19,790
which is fun is that the signal noise

296
00:11:24,639 --> 00:11:21,770
actually from the 2012 data to the

297
00:11:26,110 --> 00:11:24,649
2014-2015 day is drastically increased

298
00:11:28,690 --> 00:11:26,120
and that's because the omo array has

299
00:11:30,250 --> 00:11:28,700
basically doubled in size so almost

300
00:11:33,040 --> 00:11:30,260
becoming a very powerful tool and this

301
00:11:34,600 --> 00:11:33,050
is really exciting to see so we know

302
00:11:37,449 --> 00:11:34,610
that carbon monoxide is fairly well

303
00:11:39,760 --> 00:11:37,459
mixed in Titan's atmosphere has about 50

304
00:11:41,470 --> 00:11:39,770
parts per million up and down all the

305
00:11:42,579 --> 00:11:41,480
way because it's pretty impervious to

306
00:11:44,680 --> 00:11:42,589
photodissociation

307
00:11:46,600 --> 00:11:44,690
and so that allows us to say any

308
00:11:48,130 --> 00:11:46,610
variations in the spectra are due to

309
00:11:50,050 --> 00:11:48,140
temperature and so we can pull out these

310
00:11:51,280 --> 00:11:50,060
temperature profiles this is what

311
00:11:54,310 --> 00:11:51,290
Titan's atmosphere temperature looks

312
00:11:55,960 --> 00:11:54,320
like has this mesosphere up here and

313
00:11:57,519 --> 00:11:55,970

then the stratopause down here

314
00:12:00,400 --> 00:11:57,529
stratosphere and then the tropopause is

315
00:12:02,440 --> 00:12:00,410
below which is as Alex said previously

316
00:12:05,590 --> 00:12:02,450
mostly where we see kind of the weather

317
00:12:07,240 --> 00:12:05,600
effects right so these variations look

318
00:12:08,949 --> 00:12:07,250
pretty minor around here and this is not

319
00:12:10,840 --> 00:12:08,959
a great way to diagnose these but if you

320
00:12:13,180 --> 00:12:10,850
dig in further you can actually see that

321
00:12:14,949 --> 00:12:13,190
as we go forward in time Titans

322
00:12:17,340 --> 00:12:14,959
upper atmosphere in the north gets

323
00:12:22,150 --> 00:12:17,350
warmer and this is due just to increased

324
00:12:23,710 --> 00:12:22,160
insulation and in the southern portions

325
00:12:25,569 --> 00:12:23,720
of the disk we actually see the lower

326
00:12:27,430 --> 00:12:25,579
atmosphere getting warmer and again this

327
00:12:30,100 --> 00:12:27,440
is due to this kind of downwelling of

328
00:12:31,630 --> 00:12:30,110
the atmosphere near the winter pole and

329
00:12:34,030 --> 00:12:31,640
so Titan has this kind of like large

330
00:12:35,500 --> 00:12:34,040
Hadley circulation that kind of circular

331
00:12:36,550 --> 00:12:35,510
rises this around so emerging paper

332
00:12:38,170 --> 00:12:36,560
about this right now than other

333
00:12:40,420 --> 00:12:38,180
variations comparing these to Cassini

334
00:12:42,670 --> 00:12:40,430
but what may be more interesting to use

335
00:12:44,170 --> 00:12:42,680
some future work where I'll try to pull

336
00:12:45,040 --> 00:12:44,180
out a bunch of different chemical

337
00:12:47,079 --> 00:12:45,050
abundance profiles

338
00:12:48,579 --> 00:12:47,089

these are pretty preliminary and I

339
00:12:50,530 --> 00:12:48,589
haven't plugged in the temperatures from

340
00:12:53,170 --> 00:12:50,540
the previous study but this is kind of

341
00:12:54,340 --> 00:12:53,180
what you would do would be to use the

342
00:12:55,810 --> 00:12:54,350
temperatures that you find in these

343
00:12:58,180 --> 00:12:55,820
different regions and then try to

344
00:13:01,720 --> 00:12:58,190
extract abundance profiles at a various

345
00:13:04,750 --> 00:13:01,730
different molecules so here we have HC 3

346
00:13:08,019 --> 00:13:04,760
and and then C 3 H 4 and CH 3 CN

347
00:13:10,180 --> 00:13:08,029
profiles in the north the center and the

348
00:13:11,380 --> 00:13:10,190
south and you don't study this again but

349
00:13:13,600 --> 00:13:11,390
basically what we're seeing is that

350
00:13:16,199 --> 00:13:13,610
there's enhanced abundances of a lot of

351
00:13:18,730 --> 00:13:16,209
different molecules in the poles and

352
00:13:20,290 --> 00:13:18,740
that's mostly due to this kind of

353
00:13:22,000 --> 00:13:20,300
circular

354
00:13:24,820 --> 00:13:22,010
Hadley cell thing going on and

355
00:13:26,740 --> 00:13:24,830
downwelling into the polls and to see

356
00:13:28,750 --> 00:13:26,750
different abundance enhancements there's

357
00:13:30,370 --> 00:13:28,760
is really interesting and feeds into the

358
00:13:33,370 --> 00:13:30,380
kind of permanent leg features that are

359
00:13:36,810 --> 00:13:33,380
in Titan's polls so this is exciting and

360
00:13:38,710 --> 00:13:36,820
in summary you can detect new

361
00:13:40,990 --> 00:13:38,720
potentially as four biologically

362
00:13:43,150 --> 00:13:41,000
significant molecules with oma in

363
00:13:46,090 --> 00:13:43,160

Titan's atmosphere and you can both

364
00:13:48,970 --> 00:13:46,100
measure spatial temperature and also

365
00:13:50,740 --> 00:13:48,980
abundance variations of these species

366
00:13:52,990 --> 00:13:50,750
and then do that over time and compare

367
00:13:54,670 --> 00:13:53,000
these to previous measurements for

368
00:13:58,870 --> 00:13:54,680
reference the temperatures that go so

369
00:14:02,320 --> 00:13:58,880
far agree to Cassini series radio other

370
00:14:04,660 --> 00:14:02,330
stuff within five Kelvin so I think that

371
00:14:06,220 --> 00:14:04,670
they're pretty robust so far and with

372
00:14:08,260 --> 00:14:06,230
these correct spatial temperatures you

373
00:14:10,269 --> 00:14:08,270
can get abundance things so with that

374
00:14:12,190 --> 00:14:10,279
like to acknowledge my funding support

375
00:14:14,470 --> 00:14:12,200
through in NASA J GFP and some

376
00:14:17,920 --> 00:14:14,480
additional Alma stuff and with that I'd

377
00:14:21,400 --> 00:14:17,930
like to give bonus talk damn it there it

378
00:14:23,980 --> 00:14:21,410
is okay so so this talk is just useless

379
00:14:25,150 --> 00:14:23,990
don't get scared but I was at the PWR

380
00:14:29,319 --> 00:14:25,160
this weekend and I saw a lot of people

381
00:14:32,350 --> 00:14:29,329
talking about their proposed projects

382
00:14:34,900 --> 00:14:32,360
with this kind of emphasis on this can

383
00:14:36,970 --> 00:14:34,910
help support additional spacecraft

384
00:14:39,639 --> 00:14:36,980
missions to places this is a good add-on

385
00:14:40,600 --> 00:14:39,649
to the development of spacecraft I want

386
00:14:42,610 --> 00:14:40,610
to talk about that a little bit because

387
00:14:44,920 --> 00:14:42,620
I haven't seen a lot of this talk here

388
00:14:47,290 --> 00:14:44,930

and I was part of this really cool

389
00:14:50,670 --> 00:14:47,300
project with New Mexico State which was

390
00:14:52,810 --> 00:14:50,680
to build a CubeSat to go aboard the

391
00:14:53,980 --> 00:14:52,820
Europa clipper mission and this is not

392
00:14:55,660 --> 00:14:53,990
actually gonna happen it was a concept

393
00:14:57,490 --> 00:14:55,670
study but they kind of called on a bunch

394
00:14:59,860 --> 00:14:57,500
of universities and I personally felt

395
00:15:02,800 --> 00:14:59,870
like it was a great way to get involved

396
00:15:04,870 --> 00:15:02,810
in taking your science making it

397
00:15:07,240 --> 00:15:04,880
manageable making it small and then

398
00:15:08,920 --> 00:15:07,250
saying this is something I can only do

399
00:15:10,750 --> 00:15:08,930
from space and keeps that's really

400
00:15:13,030 --> 00:15:10,760
allowed you to do that they're small and

401
00:15:14,170 --> 00:15:13,040
they're cheap and they're modular so you

402
00:15:16,389 --> 00:15:14,180
basically take a bunch of commercial

403
00:15:17,650 --> 00:15:16,399
components and put them together and you

404
00:15:20,380 --> 00:15:17,660
can build this kind of like a lego

405
00:15:22,120 --> 00:15:20,390
satellite and some of these may go on

406
00:15:24,550 --> 00:15:22,130
future missions there have been a couple

407
00:15:26,199 --> 00:15:24,560
accepted for Mars which will be the

408
00:15:27,699 --> 00:15:26,209
first interplanetary keep sets as we

409
00:15:28,960 --> 00:15:27,709
call them Marco so if you want to know

410
00:15:30,130 --> 00:15:28,970
anything more about cube sets you can

411
00:15:31,300 --> 00:15:30,140
come talk to me later we can kind of

412
00:15:32,710 --> 00:15:31,310
spit ball about how you can take your

413
00:15:36,069 --> 00:15:32,720

science and really

414
00:15:37,420 --> 00:15:36,079
move it into space on a micro scale

415
00:15:39,670 --> 00:15:37,430
which is really exciting so for

416
00:15:41,470 --> 00:15:39,680
reference our cube set that we developed

417
00:15:42,759 --> 00:15:41,480
was the deployable atmospheric

418
00:15:44,949 --> 00:15:42,769
reconnaissance CubeSat with sputtering

419
00:15:49,269 --> 00:15:44,959
iron detector or darkside and that is my

420
00:15:52,030 --> 00:15:49,279
acronym and so this is what Darkseid

421
00:15:54,189 --> 00:15:52,040
does it has this deployable solar panel

422
00:15:57,730 --> 00:15:54,199
array which folds out into this large

423
00:16:01,210 --> 00:15:57,740
drag wall and essentially does a flyby

424
00:16:02,590 --> 00:16:01,220
of Europa and as it does this with these

425
00:16:04,329 --> 00:16:02,600
panels that it's able to measure

426
00:16:06,160 --> 00:16:04,339
atmospheric density because the CubeSat

427
00:16:07,749 --> 00:16:06,170
is so small and very light so if you

428
00:16:09,040 --> 00:16:07,759
increase the surface area you get much

429
00:16:11,290 --> 00:16:09,050
more drag measurement of it with an

430
00:16:12,970 --> 00:16:11,300
accelerometer in addition to that has an

431
00:16:14,559 --> 00:16:12,980
ion detector which can detect this kind

432
00:16:16,240 --> 00:16:14,569
of magnetospheric interactions with your

433
00:16:17,800 --> 00:16:16,250
rope as it does this flyby so this was

434
00:16:19,569 --> 00:16:17,810
really fun and if you're interested in

435
00:16:21,490 --> 00:16:19,579
talking more about cube sets I'd be

436
00:16:33,340 --> 00:16:21,500
happy to do that and with that I will

437
00:16:36,249 --> 00:16:33,350
take questions thank you that was

438
00:16:38,410 --> 00:16:36,259

awesome thanks appreciate it so I have a

439
00:16:40,780 --> 00:16:38,420
quick question I'm wondering a little

440
00:16:41,889 --> 00:16:40,790
bit and gentle to the talk but do you

441
00:16:44,290 --> 00:16:41,899
know of anyone that's actually looking

442
00:16:46,030 --> 00:16:44,300
at ocean circulation for the two types

443
00:16:48,460 --> 00:16:46,040
of oceans on Titan the communication

444
00:16:50,230 --> 00:16:48,470
between them in terms of circulation do

445
00:16:52,329 --> 00:16:50,240
you mean the subsurface ocean they're

446
00:16:53,980 --> 00:16:52,339
going to liquid lake features on the top

447
00:16:56,350 --> 00:16:53,990
the communication between those is

448
00:16:58,689 --> 00:16:56,360
anyone who looked at the flux rates I

449
00:17:01,090 --> 00:16:58,699
don't know too much about the subsurface

450
00:17:04,299 --> 00:17:01,100
ocean stuff I think most of it before

451
00:17:06,210 --> 00:17:04,309
Cassini was just kind of modeling and I

452
00:17:09,399 --> 00:17:06,220
mean since then we have no real idea of

453
00:17:10,870 --> 00:17:09,409
how to constrain anything observation

454
00:17:13,090 --> 00:17:10,880
only right so most of the stuff that we

455
00:17:16,270 --> 00:17:13,100
have about the subsurface ocean is from

456
00:17:18,279 --> 00:17:16,280
Cassini flybys so yeah I don't know too

457
00:17:19,659 --> 00:17:18,289
much about that there may have been some

458
00:17:21,309 --> 00:17:19,669
modeling of feedback between there I

459
00:17:23,230 --> 00:17:21,319
know there are a lot of unexplained kind

460
00:17:25,090 --> 00:17:23,240
of abundances and you know how do we get

461
00:17:28,120 --> 00:17:25,100
extra methane as to the atmosphere is

462
00:17:30,490 --> 00:17:28,130
there cryovolcanism is there outgassing

463
00:17:33,279 --> 00:17:30,500

other stuff so I think the subsurface Oh

464
00:17:34,870 --> 00:17:33,289
should could play into that yeah yeah

465
00:17:37,000 --> 00:17:34,880
follow up can I make a quick plug for

466
00:17:38,830 --> 00:17:37,010
your CubeSat program absolutely okay

467
00:17:41,200 --> 00:17:38,840
just really quick for everybody in here

468
00:17:42,490 --> 00:17:41,210
everybody in here qualifies and you can

469
00:17:45,340 --> 00:17:42,500
actually make an application that will

470
00:17:45,690 --> 00:17:45,350
be a call for for proposals for the

471
00:17:48,139 --> 00:17:45,700
report

472
00:17:52,580 --> 00:17:48,149
ramit Goddard Space Flight Center in

473
00:17:55,289 --> 00:17:52,590
stmd space technology called Nayak NASA

474
00:17:56,759 --> 00:17:55,299
innovative advanced concepts so if you

475
00:17:58,019 --> 00:17:56,769
have an idea you don't have to go

476
00:17:59,820 --> 00:17:58,029
through a pie you don't have to go

477
00:18:02,879 --> 00:17:59,830
through anybody you can actually apply

478
00:18:04,200 --> 00:18:02,889
directly it's up to $650,000 and grant

479
00:18:06,570 --> 00:18:04,210
money for you to develop technologies

480
00:18:08,539 --> 00:18:06,580
and ideas so if you're interested in

481
00:18:11,159 --> 00:18:08,549
that just find me and I'll help you out

482
00:18:12,149 --> 00:18:11,169
yeah do that thank you for saying that

483
00:18:13,500 --> 00:18:12,159
that's really cool

484
00:18:14,940 --> 00:18:13,510
cube sets are a great way to get

485
00:18:15,990 --> 00:18:14,950
involved in this and also it's kind of

486
00:18:17,879 --> 00:18:16,000
on the cutting edge so if you're looking

487
00:18:19,860 --> 00:18:17,889
for something to kind of push your CV

488
00:18:20,460 --> 00:18:19,870

check that out it'll take one more

489
00:18:24,240 --> 00:18:20,470
question

490
00:18:25,799 --> 00:18:24,250
all right great talk um if you go to

491
00:18:30,149 --> 00:18:25,809
where you're talking about the abundance

492
00:18:31,649 --> 00:18:30,159
variations yeah so how much of that do

493
00:18:33,960 --> 00:18:31,659
you think is complicated by optical

494
00:18:35,190 --> 00:18:33,970
depth effects how how optically thick

495
00:18:36,720 --> 00:18:35,200
are these species and how much will that

496
00:18:40,529 --> 00:18:36,730
affect being able to pull that back out

497
00:18:43,230 --> 00:18:40,539
good question so the as you saw the the

498
00:18:45,180 --> 00:18:43,240
co lines that I'm modeling are you know

499
00:18:47,399 --> 00:18:45,190
super pressure broadened right and so I

500
00:18:49,620 --> 00:18:47,409
you know basically just because we know

501
00:18:51,450 --> 00:18:49,630
the vertical abundance of that means

502
00:18:53,310 --> 00:18:51,460
that we can safely say like this isn't

503
00:18:56,039 --> 00:18:53,320
super jet generate with with abundance

504
00:18:57,680 --> 00:18:56,049
variations fortunately for us most of

505
00:19:00,870 --> 00:18:57,690
these things are actually not very

506
00:19:03,120 --> 00:19:00,880
optically thick and so there are very

507
00:19:05,220 --> 00:19:03,130
thin lines not very broadened with the

508
00:19:07,350 --> 00:19:05,230
exception of hydrogen cyanide and

509
00:19:09,029 --> 00:19:07,360
hydrogen cyanide proved to be quite

510
00:19:11,669 --> 00:19:09,039
formidable and doing this kind of

511
00:19:14,039 --> 00:19:11,679
radiative transfer so I'm worried that

512
00:19:16,110 --> 00:19:14,049
some of these little kind of bulges here

513
00:19:17,460 --> 00:19:16,120

are due to inaccurate temperatures and

514
00:19:19,769 --> 00:19:17,470
that will be something interesting to

515
00:19:20,940 --> 00:19:19,779
see but yeah htm' we have to be careful

516
00:19:23,700 --> 00:19:20,950
and everything else I think is actually

517
00:19:26,250 --> 00:19:23,710
the modeling seems to be pretty robust

518
00:19:27,269 --> 00:19:26,260
with that we can talk more about a layer

519
00:19:30,389 --> 00:19:27,279
that didn't answer your question up

520
00:19:31,240 --> 00:19:30,399
Thanks cool that let's think the speaker