The Venus Dialogues: Getting to Know Our Neighbor - Progress & Prospects for New Venus Research

1
00:00:04,390 --> 00:00:01,750
good morning everyone

2
00:00:05,590 --> 00:00:04,400
i'm tim lyons and welcome to getting to

3
00:00:07,829 --> 00:00:05,600
know

4
00:00:10,470 --> 00:00:07,839
our neighbor progress in prospects and a

5
00:00:12,709 --> 00:00:10,480
new generation of venus research

6
00:00:14,950 --> 00:00:12,719
i know that we all know well

7
00:00:17,029 --> 00:00:14,960
the many exciting conversations and

8
00:00:18,150 --> 00:00:17,039
mission announcements etc surrounding

9
00:00:20,550 --> 00:00:18,160
venus

10
00:00:22,310 --> 00:00:20,560
really exciting times

11
00:00:24,710 --> 00:00:22,320
so we put together

12
00:00:25,670 --> 00:00:24,720
an unfortunately short but loaded and

13
00:00:27,349 --> 00:00:25,680

exciting

14
00:00:29,269 --> 00:00:27,359
session that touches upon many of the

15
00:00:30,950 --> 00:00:29,279
highlights

16
00:00:32,709 --> 00:00:30,960
and so we're really going to just jump

17
00:00:34,790 --> 00:00:32,719
right into it so that we can save some

18
00:00:35,510 --> 00:00:34,800
time for discussion at the end and the

19
00:00:38,069 --> 00:00:35,520
uh

20
00:00:39,270 --> 00:00:38,079
the one procedural note is that all the

21
00:00:41,030 --> 00:00:39,280
discussion will be at the end we'll

22
00:00:43,350 --> 00:00:41,040
bring up the three speakers that are

23
00:00:45,590 --> 00:00:43,360
here and the two virtual speakers will

24
00:00:47,350 --> 00:00:45,600
be available as well

25
00:00:49,110 --> 00:00:47,360
so without further ado i'm going to go

26
00:00:51,430 --> 00:00:49,120
ahead and introduce our first speaker

27
00:00:53,510 --> 00:00:51,440
who is a virtual um

28
00:00:56,069 --> 00:00:53,520
member of the of the team

29
00:00:57,990 --> 00:00:56,079
and that is candace lee jessup from

30
00:00:59,189 --> 00:00:58,000
southwest research institute and she is

31
00:01:02,950 --> 00:00:59,199
going to give us

32
00:01:06,469 --> 00:01:02,960
an overview entitled the venus story

33
00:01:13,030 --> 00:01:09,190
good morning everyone

34
00:01:17,830 --> 00:01:13,040
i am hopeful that you can hear me

35
00:01:22,070 --> 00:01:21,109
okay so i am giving an overview

36
00:01:24,870 --> 00:01:22,080
um

37
00:01:27,190 --> 00:01:24,880
but not of venus in general i'm giving

38
00:01:28,630 --> 00:01:27,200

an overview of

39
00:01:31,510 --> 00:01:28,640
um

40
00:01:32,950 --> 00:01:31,520
past and present habitability of venus

41
00:01:36,069 --> 00:01:32,960
really what i'm going to be talking

42
00:01:37,990 --> 00:01:36,079
about is how do we frame venus as an

43
00:01:41,830 --> 00:01:38,000
astrobiology target so that's what i'm

44
00:01:43,670 --> 00:01:41,840
going to be talking to you about today

45
00:01:45,749 --> 00:01:43,680
and i apologize for my

46
00:01:47,030 --> 00:01:45,759
camera as well

47
00:01:48,710 --> 00:01:47,040
okay so

48
00:01:49,590 --> 00:01:48,720
i'll just start out with the things that

49
00:01:51,109 --> 00:01:49,600
i think

50
00:01:52,710 --> 00:01:51,119
a lot of people who follow this

51
00:01:54,789 --> 00:01:52,720
conversation now

52
00:01:57,270 --> 00:01:54,799
which is that they're

53
00:01:59,830 --> 00:01:57,280
a set of criteria to define a

54
00:02:01,030 --> 00:01:59,840
habitability for a planet

55
00:02:03,190 --> 00:02:01,040
um

56
00:02:05,350 --> 00:02:03,200
one of the most important is as we all

57
00:02:08,389 --> 00:02:05,360
know the idea of following the water the

58
00:02:10,469 --> 00:02:08,399
importance of water as a solvent for

59
00:02:11,910 --> 00:02:10,479
biochemical processes

60
00:02:14,229 --> 00:02:11,920
and so

61
00:02:16,150 --> 00:02:14,239
there needs to be water

62
00:02:18,229 --> 00:02:16,160
in at the planet that you want to

63
00:02:20,869 --> 00:02:18,239

research and there needs to be

64
00:02:22,949 --> 00:02:20,879
have been water in contact with the

65
00:02:25,589 --> 00:02:22,959
surface for a long period of time so

66
00:02:28,150 --> 00:02:25,599
there's been enough time for biological

67
00:02:30,229 --> 00:02:28,160
processes to begin

68
00:02:34,070 --> 00:02:30,239
the key thing about habitability is that

69
00:02:36,470 --> 00:02:34,080
the environment itself is hospitable to

70
00:02:39,910 --> 00:02:36,480
bile elements in other words it's not

71
00:02:41,750 --> 00:02:39,920
annihilating and the characteristics we

72
00:02:47,110 --> 00:02:41,760
care about there are temperature and

73
00:02:50,550 --> 00:02:48,550
there's more but i can't think of them

74
00:02:51,430 --> 00:02:50,560
because i haven't had enough sleep

75
00:02:53,350 --> 00:02:51,440
um

76
00:02:56,309 --> 00:02:53,360
but we i think we all know these things

77
00:02:58,869 --> 00:02:56,319
another key element of um

78
00:03:00,470 --> 00:02:58,879
a habitable zone is one one that

79
00:03:04,390 --> 00:03:00,480
actually has life activity and one

80
00:03:06,790 --> 00:03:04,400
that's actually habitable is the um the

81
00:03:09,509 --> 00:03:06,800
idea of uh disequilibrium life needs

82
00:03:12,869 --> 00:03:09,519
this equilibrium to function it actually

83
00:03:15,190 --> 00:03:12,879
is in a disequilibrium state and it also

84
00:03:16,550 --> 00:03:15,200
feeds off of this equilibrium within its

85
00:03:18,149 --> 00:03:16,560
environment

86
00:03:19,990 --> 00:03:18,159
so those are sort of

87
00:03:22,149 --> 00:03:20,000
the framework of how we look at

88
00:03:25,430 --> 00:03:22,159

habitability when we're thinking about a

89
00:03:27,030 --> 00:03:25,440
particular planet and whether or not how

90
00:03:30,070 --> 00:03:27,040
it fits into the idea of being an

91
00:03:33,830 --> 00:03:30,080
astrobiology target

92
00:03:37,910 --> 00:03:33,840
so venus is infamous for having a very

93
00:03:38,869 --> 00:03:37,920
parched um surface currently um having

94
00:03:40,949 --> 00:03:38,879
strong

95
00:03:43,430 --> 00:03:40,959
high pressure and high temperature and

96
00:03:45,350 --> 00:03:43,440
so it's sort of the epitome of what we

97
00:03:47,589 --> 00:03:45,360
think of as a hostile environment at the

98
00:03:50,070 --> 00:03:47,599
surface however i want to point out that

99
00:03:52,390 --> 00:03:50,080
while there isn't any liquid water on

100
00:03:54,789 --> 00:03:52,400
the surface there is water below the

101
00:03:57,750 --> 00:03:54,799
cloud depth in the region between 0 and

102
00:04:01,350 --> 00:03:57,760
47 kilometers water has been detected

103
00:04:03,030 --> 00:04:01,360
and it's most likely presumably from

104
00:04:04,710 --> 00:04:03,040
being vented directly out of the

105
00:04:06,070 --> 00:04:04,720
volcanoes

106
00:04:07,350 --> 00:04:06,080
so

107
00:04:09,429 --> 00:04:07,360
with this

108
00:04:12,789 --> 00:04:09,439
lack of surface water which is a key

109
00:04:14,949 --> 00:04:12,799
element of being a habitable zone then

110
00:04:17,590 --> 00:04:14,959
what are what element of venus do we

111
00:04:19,030 --> 00:04:17,600
consider to be currently habitable and

112
00:04:21,590 --> 00:04:19,040
that will be the cloud there's been a

113
00:04:23,510 --> 00:04:21,600

lot of speculation for a long time

114
00:04:26,070 --> 00:04:23,520
about whether or not the clouds can be a

115
00:04:28,710 --> 00:04:26,080
life habitat and while i will get into

116
00:04:31,030 --> 00:04:28,720
the environmental conditions that drive

117
00:04:33,110 --> 00:04:31,040
that conversation one of the most basic

118
00:04:35,270 --> 00:04:33,120
things that drives that conversation

119
00:04:37,430 --> 00:04:35,280
is the fact that venus is what i would

120
00:04:38,469 --> 00:04:37,440
call an aerosol nursery

121
00:04:40,950 --> 00:04:38,479
um

122
00:04:44,469 --> 00:04:40,960
between 30 and 47 kilometers you have a

123
00:04:46,390 --> 00:04:44,479
lot of haze between 47 and 60 kilometers

124
00:04:49,189 --> 00:04:46,400
or 70 kilometers you have the cloud

125
00:04:50,629 --> 00:04:49,199
layers above 70 kilometers about 90

126
00:04:53,270 --> 00:04:50,639
kilometers you have another layer of

127
00:04:55,749 --> 00:04:53,280
haze and so you just have a lot of

128
00:04:58,469 --> 00:04:55,759
aerosols and particulates and what we

129
00:04:59,430 --> 00:04:58,479
know to be true from the earth is that

130
00:05:01,029 --> 00:04:59,440
um

131
00:05:02,790 --> 00:05:01,039
microorganisms within the earth's

132
00:05:05,510 --> 00:05:02,800
biosphere whether it's

133
00:05:08,390 --> 00:05:05,520
if um in in the air in the atmosphere

134
00:05:11,510 --> 00:05:08,400
whether it's in the sea it attaches to

135
00:05:12,790 --> 00:05:11,520
particulates so just based on the

136
00:05:15,670 --> 00:05:12,800
aerosol

137
00:05:17,830 --> 00:05:15,680
content alone it's it's it's a

138
00:05:19,510 --> 00:05:17,840

reasonable thing to speculate about

139
00:05:21,110 --> 00:05:19,520
whether or not the habitat within the

140
00:05:24,550 --> 00:05:21,120
clouds is

141
00:05:28,310 --> 00:05:26,070
to life

142
00:05:30,629 --> 00:05:28,320
so what do we what do we know so the

143
00:05:31,510 --> 00:05:30,639
things that we know for sure that life

144
00:05:34,550 --> 00:05:31,520
needs

145
00:05:37,510 --> 00:05:34,560
are the basic elements of life the

146
00:05:40,550 --> 00:05:37,520
carbon nitrogen hydrogen oxygen

147
00:05:42,150 --> 00:05:40,560
phosphorus sulfur so sulfur

148
00:05:43,590 --> 00:05:42,160
and

149
00:05:46,629 --> 00:05:43,600
through various missions that have

150
00:05:49,189 --> 00:05:46,639
already been at venus we have a lot of

151
00:05:51,830 --> 00:05:49,199
information not only on the bulk gas

152
00:05:54,150 --> 00:05:51,840
species but on trace gas species many of

153
00:05:57,430 --> 00:05:54,160
which have each of these elements in

154
00:05:59,110 --> 00:05:57,440
them and so we know that the

155
00:06:02,150 --> 00:05:59,120
constituents

156
00:06:03,430 --> 00:06:02,160
within the cloud layer specifically um

157
00:06:05,270 --> 00:06:03,440
are

158
00:06:07,029 --> 00:06:05,280
have the necessary elements in it and i

159
00:06:09,110 --> 00:06:07,039
would say there's a step beyond just

160
00:06:12,469 --> 00:06:09,120
having the necessary elements of life

161
00:06:14,070 --> 00:06:12,479
but specific biomarkers have actually

162
00:06:16,309 --> 00:06:14,080
that we know are building blocks for

163
00:06:18,230 --> 00:06:16,319

life exists there such as phosphorus and

164
00:06:19,350 --> 00:06:18,240
cos

165
00:06:21,110 --> 00:06:19,360
the other thing

166
00:06:23,350 --> 00:06:21,120
about the cloud layers is that it's a

167
00:06:25,110 --> 00:06:23,360
temperate zone it's again it's a it's

168
00:06:28,629 --> 00:06:25,120
not a hostile zone but it's a friendly

169
00:06:30,309 --> 00:06:28,639
zone um the temperature and the pressure

170
00:06:32,790 --> 00:06:30,319
are similar to

171
00:06:35,029 --> 00:06:32,800
the surface temperatures and pressures

172
00:06:37,510 --> 00:06:35,039
on the earth where we where we know that

173
00:06:39,830 --> 00:06:37,520
we have an active biosphere but in

174
00:06:42,309 --> 00:06:39,840
addition to the temperate and clinic

175
00:06:43,510 --> 00:06:42,319
conditions within the clouds we also

176
00:06:46,550 --> 00:06:43,520
have

177
00:06:48,469 --> 00:06:46,560
um the radiation environment so if

178
00:06:50,629 --> 00:06:48,479
you're thinking about between 50 and 60

179
00:06:51,670 --> 00:06:50,639
kilometers the amount of uv light that

180
00:06:54,469 --> 00:06:51,680
actually

181
00:06:57,270 --> 00:06:54,479
impacts that altitude range is less than

182
00:06:59,510 --> 00:06:57,280
what would be considered annihilating to

183
00:07:02,790 --> 00:06:59,520
to life and so the radiation environment

184
00:07:05,029 --> 00:07:02,800
is also friendly um the ph environment

185
00:07:07,430 --> 00:07:05,039
while it's high

186
00:07:09,909 --> 00:07:07,440
is also relative well i should say the

187
00:07:12,230 --> 00:07:09,919
acidity ph of low acidity is high is

188
00:07:14,070 --> 00:07:12,240

also friendly i would say quote unquote

189
00:07:16,150 --> 00:07:14,080
in the sense that it's not outside of

190
00:07:18,390 --> 00:07:16,160
the limits for acetophiles or

191
00:07:20,629 --> 00:07:18,400
extremophiles on the earth

192
00:07:22,309 --> 00:07:20,639
what we don't know is whether or not the

193
00:07:24,950 --> 00:07:22,319
water content

194
00:07:27,430 --> 00:07:24,960
um within the clouds is sufficient to

195
00:07:29,430 --> 00:07:27,440
sustain life we know that water is there

196
00:07:31,110 --> 00:07:29,440
um we know that at least 30 parts per

197
00:07:33,510 --> 00:07:31,120
million has been

198
00:07:35,749 --> 00:07:33,520
detected at the base of the cloud layer

199
00:07:38,629 --> 00:07:35,759
and we know that the aerosols themselves

200
00:07:40,790 --> 00:07:38,639
are actually a solution of h2so4 in

201
00:07:42,469 --> 00:07:40,800
water so we know that water is there

202
00:07:44,230 --> 00:07:42,479
but what we don't know

203
00:07:46,070 --> 00:07:44,240
since number one we don't know if

204
00:07:48,390 --> 00:07:46,080
there's any bacteria in there so we

205
00:07:50,390 --> 00:07:48,400
don't actually know its reproductive

206
00:07:53,110 --> 00:07:50,400
rate and then additionally because the

207
00:07:56,070 --> 00:07:53,120
water that is there is so much lower

208
00:07:58,550 --> 00:07:56,080
than what's in our own earth's biosphere

209
00:08:00,629 --> 00:07:58,560
what we don't know is whether or not any

210
00:08:02,390 --> 00:08:00,639
bacteria that lives there the rate at

211
00:08:05,510 --> 00:08:02,400
which it would reproduce

212
00:08:07,430 --> 00:08:05,520
given the parsity of water that the

213
00:08:10,070 --> 00:08:07,440

bacteria may be in

214
00:08:11,830 --> 00:08:10,080
and so that's a big deal um not knowing

215
00:08:13,990 --> 00:08:11,840
that reproductive rate but that's

216
00:08:16,230 --> 00:08:14,000
something that needs to be

217
00:08:18,390 --> 00:08:16,240
explored in the lab creating venous

218
00:08:20,230 --> 00:08:18,400
conditions and then looking at micro

219
00:08:23,189 --> 00:08:20,240
species and seeing how does the

220
00:08:25,589 --> 00:08:23,199
reproductive how is the reproductivity

221
00:08:27,350 --> 00:08:25,599
impacted by the amount of water and then

222
00:08:29,589 --> 00:08:27,360
the other key thing that we need to

223
00:08:31,110 --> 00:08:29,599
understand because we're talking about

224
00:08:33,670 --> 00:08:31,120
life in the clouds

225
00:08:37,430 --> 00:08:35,029
whether or not

226
00:08:40,149 --> 00:08:37,440
uh life in the clouds could remain in

227
00:08:41,829 --> 00:08:40,159
the clouds and have a reproductive cycle

228
00:08:43,829 --> 00:08:41,839
that is shorter than the amount of time

229
00:08:45,509 --> 00:08:43,839
that particulates might fall out of the

230
00:08:47,430 --> 00:08:45,519
class

231
00:08:49,190 --> 00:08:47,440
so

232
00:08:50,710 --> 00:08:49,200
those are the things that we don't know

233
00:08:52,230 --> 00:08:50,720
but the things that i'm showing on the

234
00:08:54,470 --> 00:08:52,240
screen are the things that we do know

235
00:08:57,590 --> 00:08:54,480
which is that sort of in general it's a

236
00:09:02,470 --> 00:08:59,910
another thing that we sort of identified

237
00:09:05,990 --> 00:09:02,480
as a criteria or characteristic of a

238
00:09:09,030 --> 00:09:06,000

habitable environment is the evidence of

239
00:09:11,430 --> 00:09:09,040
disequilibrium as i said earlier and we

240
00:09:16,230 --> 00:09:11,440
know that for example within the cloud

241
00:09:19,670 --> 00:09:16,240
layer there's both h2s h2s and so2

242
00:09:21,590 --> 00:09:19,680
and h2s would be reducing to sa2 um if

243
00:09:24,790 --> 00:09:21,600
it was in equilibrium there would not be

244
00:09:27,350 --> 00:09:24,800
so2 but in fact the fact that h2s and

245
00:09:29,430 --> 00:09:27,360
the so2 coexist in cloud layer is

246
00:09:31,590 --> 00:09:29,440
evidence that there are disc equilibrium

247
00:09:34,230 --> 00:09:31,600
processes occurring within the cloud

248
00:09:37,030 --> 00:09:34,240
layers it's similar with o2 while it

249
00:09:38,870 --> 00:09:37,040
hasn't been directly measured

250
00:09:40,790 --> 00:09:38,880
all the information that we have the

251
00:09:43,430 --> 00:09:40,800
upper limits and what the amount that we

252
00:09:45,829 --> 00:09:43,440
think may be present is not in any way

253
00:09:48,470 --> 00:09:45,839
consistent with a basic

254
00:09:51,350 --> 00:09:48,480
balanced photochemical model would

255
00:09:53,829 --> 00:09:51,360
predict and so we have these hints and

256
00:09:55,670 --> 00:09:53,839
these evidences that disequilibrium

257
00:09:58,550 --> 00:09:55,680
processes are occurring in the cloud

258
00:10:04,069 --> 00:10:01,350
so um i talked about this already

259
00:10:06,550 --> 00:10:04,079
for the sake of time which is that we

260
00:10:08,710 --> 00:10:06,560
have these conditions that we know we're

261
00:10:11,750 --> 00:10:08,720
good but we need to actually know can

262
00:10:14,310 --> 00:10:11,760
life flourish within the surface

263
00:10:16,150 --> 00:10:14,320

the other thing that we need to know is

264
00:10:18,630 --> 00:10:16,160
assuming that the

265
00:10:20,790 --> 00:10:18,640
we talk about the cloud layers being a

266
00:10:24,069 --> 00:10:20,800
habitable zone or potential

267
00:10:26,630 --> 00:10:24,079
habitat for life but

268
00:10:29,110 --> 00:10:26,640
we actually don't know if life if if in

269
00:10:31,590 --> 00:10:29,120
the past there was actually a period of

270
00:10:33,030 --> 00:10:31,600
habitability of venus we think there was

271
00:10:34,790 --> 00:10:33,040
but that's one of the key things that we

272
00:10:36,310 --> 00:10:34,800
really need to

273
00:10:38,470 --> 00:10:36,320
look into detail and have a better

274
00:10:40,069 --> 00:10:38,480
understanding of

275
00:10:41,829 --> 00:10:40,079
what we know for sure is that

276
00:10:45,509 --> 00:10:41,839
measurements both ground-based and in

277
00:10:47,829 --> 00:10:45,519
situ have detected the d h ratio and

278
00:10:51,190 --> 00:10:47,839
that ratio implies that a large quantity

279
00:10:52,550 --> 00:10:51,200
of water was lost in the past what we

280
00:10:55,190 --> 00:10:52,560
don't know is whether or not that

281
00:10:58,870 --> 00:10:55,200
quantity of water was lost in the recent

282
00:11:00,230 --> 00:10:58,880
past or over the lifetime of venus

283
00:11:02,790 --> 00:11:00,240
but we do know that there was a lot of

284
00:11:05,509 --> 00:11:02,800
water there and that was lost and

285
00:11:08,389 --> 00:11:05,519
we can also extrapolate that given that

286
00:11:10,389 --> 00:11:08,399
venus was located in the summer location

287
00:11:12,870 --> 00:11:10,399
within the solar nebula and formed at

288
00:11:14,710 --> 00:11:12,880

the same time as the earth that the

289
00:11:16,790 --> 00:11:14,720
early venus in the early earth

290
00:11:19,030 --> 00:11:16,800
conditions should be the same as it

291
00:11:21,030 --> 00:11:19,040
relates to water content

292
00:11:22,870 --> 00:11:21,040
but to get into the details of the past

293
00:11:25,430 --> 00:11:22,880
habitability what you really need to do

294
00:11:28,310 --> 00:11:25,440
is focus on climate modeling

295
00:11:29,990 --> 00:11:28,320
so i have about 53 seconds left and not

296
00:11:32,949 --> 00:11:30,000
a lot of time to talk about these

297
00:11:35,509 --> 00:11:32,959
details so i'll just say that there are

298
00:11:36,710 --> 00:11:35,519
three different types of climate bottles

299
00:11:38,310 --> 00:11:36,720
um

300
00:11:42,069 --> 00:11:38,320
there is the

301
00:11:44,069 --> 00:11:42,079
concept that there that the water

302
00:11:46,470 --> 00:11:44,079
lived on the surface for a long time in

303
00:11:49,509 --> 00:11:46,480
a shallow liquid water ocean

304
00:11:51,990 --> 00:11:49,519
and um that due to slow rotation

305
00:11:54,310 --> 00:11:52,000
that bright clouds form both on the day

306
00:11:57,350 --> 00:11:54,320
and the night side and that creates a

307
00:12:00,069 --> 00:11:57,360
buffer and a long song allows long-term

308
00:12:02,550 --> 00:12:00,079
um a long-term habitable period

309
00:12:05,190 --> 00:12:02,560
then there's been a recent paper um

310
00:12:06,710 --> 00:12:05,200
summarizing ideas that are not new but

311
00:12:09,110 --> 00:12:06,720
that in fact

312
00:12:11,030 --> 00:12:09,120
if you start modeling based on the

313
00:12:14,069 --> 00:12:11,040

accretion period where the magma ocean

314
00:12:16,069 --> 00:12:14,079
has just uh stopped then the surface is

315
00:12:18,230 --> 00:12:16,079
very high and so instead of actually

316
00:12:19,430 --> 00:12:18,240
having liquid water on the surface you

317
00:12:22,230 --> 00:12:19,440
have this

318
00:12:27,190 --> 00:12:22,240
you have a steam atmosphere

319
00:12:29,990 --> 00:12:27,200
of co2 and h2o and then what happens is

320
00:12:31,190 --> 00:12:30,000
that the infrared absorption within the

321
00:12:33,990 --> 00:12:31,200
um

322
00:12:35,590 --> 00:12:34,000
within the water steam actually creates

323
00:12:37,509 --> 00:12:35,600
so much heat that the water never

324
00:12:40,710 --> 00:12:37,519
actually condenses on the surface and

325
00:12:42,870 --> 00:12:40,720
particularly as the sun ages over time

326
00:12:45,750 --> 00:12:42,880
and so you actually never had a

327
00:12:48,150 --> 00:12:45,760
habitable zone but in fact um for an

328
00:12:49,670 --> 00:12:48,160
inhabitable habitable

329
00:12:52,949 --> 00:12:49,680
well called habitable zone at the

330
00:12:54,470 --> 00:12:52,959
surface um because uh it was too hot the

331
00:12:55,910 --> 00:12:54,480
water's condensed in the o2 actually

332
00:12:57,430 --> 00:12:55,920
went back into

333
00:12:59,990 --> 00:12:57,440
into the magma

334
00:13:02,710 --> 00:13:00,000
um and then there's an another more the

335
00:13:04,949 --> 00:13:02,720
more classical idea of how

336
00:13:06,870 --> 00:13:04,959
venus got from where we are to where

337
00:13:09,110 --> 00:13:06,880
where we're going to be which is

338
00:13:10,069 --> 00:13:09,120

um the idea that

339
00:13:12,230 --> 00:13:10,079
um

340
00:13:14,230 --> 00:13:12,240
it started out employment and then you

341
00:13:16,470 --> 00:13:14,240
know everything going on so these are

342
00:13:18,389 --> 00:13:16,480
the things that need to be explored and

343
00:13:20,470 --> 00:13:18,399
need to be better understood we need to

344
00:13:22,230 --> 00:13:20,480
understand the past

345
00:13:23,350 --> 00:13:22,240
and how

346
00:13:25,670 --> 00:13:23,360
whether or not there was ever a

347
00:13:27,509 --> 00:13:25,680
habitable period to that then informs

348
00:13:29,590 --> 00:13:27,519
our understanding of whether or not

349
00:13:32,470 --> 00:13:29,600
um it actually makes sense to talk about

350
00:13:34,870 --> 00:13:32,480
habitability in life and crowds abuse

351
00:13:36,389 --> 00:13:34,880
so i'm going to stop there because i'm

352
00:13:38,870 --> 00:13:36,399
pretty confident that

353
00:13:40,230 --> 00:13:38,880
lori will get into

354
00:13:46,629 --> 00:13:40,240
things that we can do to solve these

355
00:13:46,639 --> 00:13:53,030
thanks very much candy

356
00:13:56,870 --> 00:13:55,030
so our next speaker um and this is the

357
00:13:59,110 --> 00:13:56,880
first of two talks addressing the

358
00:14:01,030 --> 00:13:59,120
phosphine conversation

359
00:14:03,509 --> 00:14:01,040
and so our next speaker is secret ron

360
00:14:05,910 --> 00:14:03,519
ranjan from northwestern university and

361
00:14:12,150 --> 00:14:05,920
his talk is entitled phosphine on venus

362
00:14:16,230 --> 00:14:13,910
okay thanks everyone so my name is

363
00:14:17,590 --> 00:14:16,240

secret i'm a postdoc northwestern and

364
00:14:19,590 --> 00:14:17,600
now i'm going to give you a lightning

365
00:14:20,790 --> 00:14:19,600
update regarding the debate as to

366
00:14:24,389 --> 00:14:20,800
whether or not there's phosphene on

367
00:14:26,069 --> 00:14:24,399
venus and if present what it might mean

368
00:14:27,910 --> 00:14:26,079
i just wanted to orient you on what this

369
00:14:30,550 --> 00:14:27,920
debate is predicated on it's predicated

370
00:14:31,910 --> 00:14:30,560
on really two claims first is that

371
00:14:33,750 --> 00:14:31,920
there's trace

372
00:14:35,750 --> 00:14:33,760
amounts of the gas phosphine present in

373
00:14:37,910 --> 00:14:35,760
the tempered cloud decks of venus

374
00:14:39,670 --> 00:14:37,920
and second is even that trace amount of

375
00:14:42,230 --> 00:14:39,680
gas is difficult to explain with kind of

376
00:14:44,230 --> 00:14:42,240
a canonical picture of venus

377
00:14:45,430 --> 00:14:44,240
so what is the reason that we make that

378
00:14:47,269 --> 00:14:45,440
ladder claim why do we say that

379
00:14:49,030 --> 00:14:47,279
phosphine is weird on venus

380
00:14:50,470 --> 00:14:49,040
phosphine is a bit weird to find pretty

381
00:14:52,069 --> 00:14:50,480
much anywhere because it's so violently

382
00:14:54,150 --> 00:14:52,079
reactive it falls apart of the touch of

383
00:14:56,310 --> 00:14:54,160
a feather we tried to estimate what the

384
00:14:57,189 --> 00:14:56,320
production rate required to explain the

385
00:14:59,990 --> 00:14:57,199
claim

386
00:15:01,430 --> 00:15:00,000
phosphine abundance was in two ways the

387
00:15:02,710 --> 00:15:01,440
kind of the first way we did was with a

388
00:15:04,310 --> 00:15:02,720

full photochemical model that

389
00:15:06,069 --> 00:15:04,320
constitutes our best guess but we don't

390
00:15:07,430 --> 00:15:06,079
actually rely on that because the

391
00:15:08,629 --> 00:15:07,440
problem with photochemical models is

392
00:15:09,670 --> 00:15:08,639
they're complicated there's a lot of

393
00:15:11,350 --> 00:15:09,680
knobs to turn there's a bunch of

394
00:15:13,750 --> 00:15:11,360
uncertainty and so we don't want to

395
00:15:15,350 --> 00:15:13,760
depend on that what we depend on instead

396
00:15:17,269 --> 00:15:15,360
is a conservative lower bound we

397
00:15:19,350 --> 00:15:17,279
construct mostly analytically

398
00:15:20,710 --> 00:15:19,360
considering only transport to the upper

399
00:15:22,949 --> 00:15:20,720
atmosphere which we think to be pretty

400
00:15:24,389 --> 00:15:22,959
robust it's about a thousand times lower

401
00:15:26,389 --> 00:15:24,399
so it's about a thousand times easier

402
00:15:28,230 --> 00:15:26,399
for known mechanisms to explain

403
00:15:29,670 --> 00:15:28,240
that phosphine production rate and

404
00:15:31,030 --> 00:15:29,680
that's what we rely on in our

405
00:15:32,230 --> 00:15:31,040
calculations

406
00:15:34,310 --> 00:15:32,240
so we looked through a bunch of

407
00:15:35,749 --> 00:15:34,320
mechanisms that we thought might be able

408
00:15:37,269 --> 00:15:35,759
to produce phosphine there and we found

409
00:15:39,509 --> 00:15:37,279
that within the limits of our knowledge

410
00:15:41,030 --> 00:15:39,519
within our canonical picture venus and

411
00:15:43,030 --> 00:15:41,040
our current understanding of phosphine

412
00:15:45,110 --> 00:15:43,040
kinetics none of those reach even that

413
00:15:46,629 --> 00:15:45,120

relatively low bar

414
00:15:48,470 --> 00:15:46,639
so there's been other proposals in the

415
00:15:50,150 --> 00:15:48,480
literature as to other mechanisms that

416
00:15:52,150 --> 00:15:50,160
might be able to explain that level of

417
00:15:53,430 --> 00:15:52,160
phosphine production flux and i'd like

418
00:15:56,629 --> 00:15:53,440
to take a moment to go through some of

419
00:15:58,870 --> 00:15:56,639
those one of them is the idea that maybe

420
00:16:00,870 --> 00:15:58,880
maybe sufficiently weird volcanism can

421
00:16:02,629 --> 00:16:00,880
do it the idea is that in the deep

422
00:16:04,710 --> 00:16:02,639
interior of venus in the deep mantle

423
00:16:06,230 --> 00:16:04,720
phosphorus is present in reduced forms

424
00:16:08,389 --> 00:16:06,240
and if somehow you can get that reduced

425
00:16:10,629 --> 00:16:08,399
phosphorus in bulk up into the middle

426
00:16:12,230 --> 00:16:10,639
atmosphere maybe it can disproportionate

427
00:16:13,910 --> 00:16:12,240
and give you ph3

428
00:16:15,990 --> 00:16:13,920
the main challenge there is that this is

429
00:16:17,430 --> 00:16:16,000
a very unique mode of volcanism zest not

430
00:16:19,910 --> 00:16:17,440
seen on earth or predicted in

431
00:16:21,910 --> 00:16:19,920
theoretical models of volcanism and it

432
00:16:23,590 --> 00:16:21,920
requires the phosphites to not re

433
00:16:25,430 --> 00:16:23,600
equilibrate with changing temperature

434
00:16:27,430 --> 00:16:25,440
and pressure on their ascent

435
00:16:29,749 --> 00:16:27,440
uh one way to confirm this theory would

436
00:16:31,430 --> 00:16:29,759
be to detect evidence of bulk uh lower

437
00:16:33,910 --> 00:16:31,440
mental composition

438
00:16:35,910 --> 00:16:33,920

magmas on the surface of venus

439
00:16:38,150 --> 00:16:35,920
another mechanism is the idea that maybe

440
00:16:39,590 --> 00:16:38,160
we live at a special time the idea is

441
00:16:42,150 --> 00:16:39,600
that if in the recent past there was a

442
00:16:43,990 --> 00:16:42,160
large iron meteorite impactor then maybe

443
00:16:45,269 --> 00:16:44,000
that can disproportionate and give you

444
00:16:47,670 --> 00:16:45,279
uh

445
00:16:49,350 --> 00:16:47,680
and give you and explain the detected

446
00:16:51,509 --> 00:16:49,360
concentration

447
00:16:53,030 --> 00:16:51,519
that for in order to for that mechanism

448
00:16:54,949 --> 00:16:53,040
to work there's a couple of other kind

449
00:16:56,470 --> 00:16:54,959
of experimental studies we need to do

450
00:16:57,990 --> 00:16:56,480
first we need to understand what is the

451
00:16:59,749 --> 00:16:58,000
face of reduced phosphorus when it

452
00:17:01,910 --> 00:16:59,759
ablates in a relatively oxidizing

453
00:17:04,230 --> 00:17:01,920
atmosphere like venus and second we need

454
00:17:05,909 --> 00:17:04,240
to understand what happens when that

455
00:17:08,470 --> 00:17:05,919
putative reduced phosphorus is exposed

456
00:17:10,069 --> 00:17:08,480
to concentrated h2so4 in industrial

457
00:17:12,150 --> 00:17:10,079
processes on earth those conditions

458
00:17:13,669 --> 00:17:12,160
destroy ph3 can it produce it in the

459
00:17:15,990 --> 00:17:13,679
conditions in the venetian clouds i

460
00:17:17,350 --> 00:17:16,000
think experiments would be helpful there

461
00:17:18,949 --> 00:17:17,360
another mechanism that's been put

462
00:17:20,549 --> 00:17:18,959
forward is the disproportionation of

463
00:17:21,990 --> 00:17:20,559

p406

464
00:17:23,429 --> 00:17:22,000
this was a bit of a head scratcher for

465
00:17:25,029 --> 00:17:23,439
us because we actually considered that

466
00:17:27,350 --> 00:17:25,039
exact mechanism in our paper and we came

467
00:17:29,110 --> 00:17:27,360
to the opposite result fortuitously the

468
00:17:31,190 --> 00:17:29,120
authors of this paper were at this apps

469
00:17:33,110 --> 00:17:31,200
icon and we did a brief into comparison

470
00:17:35,669 --> 00:17:33,120
we determined that the basic that it all

471
00:17:37,590 --> 00:17:35,679
comes down to the thermodynamic uh gibbs

472
00:17:38,630 --> 00:17:37,600
free energy formation for one particular

473
00:17:40,630 --> 00:17:38,640
molecule

474
00:17:42,549 --> 00:17:40,640
we used the value from the nist janaf

475
00:17:44,870 --> 00:17:42,559
tables for this particular parameter and

476
00:17:45,830 --> 00:17:44,880
we and with those parameters we we both

477
00:17:47,990 --> 00:17:45,840
found that it can't really

478
00:17:49,830 --> 00:17:48,000
disproportionate however if you instead

479
00:17:52,150 --> 00:17:49,840
use a parameter from hst which is a

480
00:17:54,070 --> 00:17:52,160
commercial thermodynamics package you

481
00:17:55,510 --> 00:17:54,080
find that it can disproportionate and so

482
00:17:56,870 --> 00:17:55,520
now we're doing follow-up work trying to

483
00:17:58,710 --> 00:17:56,880
establish the prominence of both the

484
00:18:01,350 --> 00:17:58,720
values and figure out which number is it

485
00:18:03,270 --> 00:18:01,360
really and the final kind of broad set

486
00:18:05,110 --> 00:18:03,280
of mechanisms fall under the general

487
00:18:07,430 --> 00:18:05,120
heading of novel heterogeneous

488
00:18:08,870 --> 00:18:07,440

photochemistry and the idea is maybe you

489
00:18:11,270 --> 00:18:08,880
have some mineral catalysts there and

490
00:18:13,270 --> 00:18:11,280
under irradiation by uv light

491
00:18:15,430 --> 00:18:13,280
maybe they can reduce ph

492
00:18:17,430 --> 00:18:15,440
phosphorus to ph3 and experimental

493
00:18:19,070 --> 00:18:17,440
studies of this are underway

494
00:18:21,190 --> 00:18:19,080
however there's another explanation for

495
00:18:22,470 --> 00:18:21,200
venetian phosphine which is that it's

496
00:18:24,230 --> 00:18:22,480
just not there

497
00:18:25,830 --> 00:18:24,240
so with this in mind it's worth taking a

498
00:18:27,350 --> 00:18:25,840
look at the two independent lines of

499
00:18:28,630 --> 00:18:27,360
evidence for venus and critiquing where

500
00:18:31,029 --> 00:18:28,640
they're at now

501
00:18:32,710 --> 00:18:31,039
the original claim of ph3 on venus was

502
00:18:34,950 --> 00:18:32,720
basically built around the idea that

503
00:18:37,510 --> 00:18:34,960
there was a opacity detected at about

504
00:18:40,390 --> 00:18:37,520
1.1 millimeters closely aligned with the

505
00:18:42,470 --> 00:18:40,400
expected ph3 line that was in the cloud

506
00:18:44,070 --> 00:18:42,480
deck and venus and that so2 was excluded

507
00:18:45,350 --> 00:18:44,080
as a contaminant from contemporaneous

508
00:18:47,590 --> 00:18:45,360
ammo measurements

509
00:18:49,750 --> 00:18:47,600
so how is that held up well first let's

510
00:18:51,350 --> 00:18:49,760
look at the alma data the alma data

511
00:18:52,150 --> 00:18:51,360
turns out are really challenging to work

512
00:18:53,350 --> 00:18:52,160
with

513
00:18:54,710 --> 00:18:53,360

and this is a bit surprising because

514
00:18:56,230 --> 00:18:54,720
alma's more sensitive and higher

515
00:18:58,150 --> 00:18:56,240
resolution but that works against you

516
00:18:59,990 --> 00:18:58,160
when looking at a bright nearby target

517
00:19:01,510 --> 00:19:00,000
like venus it turns out that in

518
00:19:03,830 --> 00:19:01,520
particular it generates certain high

519
00:19:05,750 --> 00:19:03,840
noise baselines and whether or not you

520
00:19:07,270 --> 00:19:05,760
recover phosphate is extremely sensitive

521
00:19:09,510 --> 00:19:07,280
to how you include those baselines so

522
00:19:11,990 --> 00:19:09,520
critically there is no independent

523
00:19:13,350 --> 00:19:12,000
recovery opacity with alma

524
00:19:14,630 --> 00:19:13,360
and it depends on how you treat those

525
00:19:16,470 --> 00:19:14,640
bass lines

526
00:19:17,590 --> 00:19:16,480
the situation with jcmt is a little bit

527
00:19:19,430 --> 00:19:17,600
different that's a single dish

528
00:19:22,150 --> 00:19:19,440
instrument and there have been multiple

529
00:19:24,549 --> 00:19:22,160
recoveries of the opacity with jcmt

530
00:19:27,510 --> 00:19:24,559
but what is that opacity uh one real

531
00:19:29,909 --> 00:19:27,520
very real possibility is that it's so2

532
00:19:33,510 --> 00:19:29,919
and in a very uh in a very nice paper

533
00:19:35,510 --> 00:19:33,520
linkowskidal 2021 pointed out that the

534
00:19:37,190 --> 00:19:35,520
initial upper limits placed on so2sing

535
00:19:39,669 --> 00:19:37,200
the alma measurements aren't invalid

536
00:19:41,590 --> 00:19:39,679
because of that same baseline issue the

537
00:19:43,110 --> 00:19:41,600
data to trending method used in the in

538
00:19:44,950 --> 00:19:43,120

the initial paper

539
00:19:46,950 --> 00:19:44,960
uh diluted the line signal so those

540
00:19:48,470 --> 00:19:46,960
upper limits are not valid our

541
00:19:49,830 --> 00:19:48,480
observation team has very much taken

542
00:19:50,950 --> 00:19:49,840
this to heart

543
00:19:55,029 --> 00:19:50,960
they looked

544
00:19:56,310 --> 00:19:55,039
contemporaneous archival jcmt

545
00:19:58,230 --> 00:19:56,320
observations which seem to be more

546
00:20:00,310 --> 00:19:58,240
robust and in a paper which has just

547
00:20:02,630 --> 00:20:00,320
been accepted so far it looks like a

548
00:20:05,110 --> 00:20:02,640
measurements taken within a few days of

549
00:20:07,510 --> 00:20:05,120
the initial 1.1

550
00:20:09,750 --> 00:20:07,520
millimeter observations don't seem to

551
00:20:11,430 --> 00:20:09,760
show signs of so2

552
00:20:12,950 --> 00:20:11,440
in order to really nail this issue

553
00:20:15,510 --> 00:20:12,960
they've started we've also started a

554
00:20:17,110 --> 00:20:15,520
large gcmt program which is aimed to

555
00:20:19,750 --> 00:20:17,120
simultaneously look for multiple

556
00:20:21,909 --> 00:20:19,760
features of so2 and 1.1 millimeter

557
00:20:23,990 --> 00:20:21,919
opacity with the goal of seeing how do

558
00:20:26,149 --> 00:20:24,000
they co-vary with the idea being that if

559
00:20:27,669 --> 00:20:26,159
they co-vary it's probably so2 if they

560
00:20:29,510 --> 00:20:27,679
don't co-vary then it's a little bit

561
00:20:31,510 --> 00:20:29,520
weirder i don't say if they don't

562
00:20:33,190 --> 00:20:31,520
co-vary its ph3 because there's another

563
00:20:36,149 --> 00:20:33,200

really important argument put forward by

564
00:20:38,149 --> 00:20:36,159
linkowski at all which is that uh the

565
00:20:39,830 --> 00:20:38,159
signal is not coming from the clouds

566
00:20:41,990 --> 00:20:39,840
it's coming from the

567
00:20:43,590 --> 00:20:42,000
it's almost certainly mesospheric and if

568
00:20:45,590 --> 00:20:43,600
that is the case then it's really hard

569
00:20:47,750 --> 00:20:45,600
to assign a ph3 interpretation to the

570
00:20:49,029 --> 00:20:47,760
signal the production flux required is

571
00:20:51,510 --> 00:20:49,039
just too high

572
00:20:52,630 --> 00:20:51,520
uh bar a few uh by a few kind of weird

573
00:20:54,710 --> 00:20:52,640
edge cases

574
00:20:56,630 --> 00:20:54,720
but then the question is what is it if

575
00:20:58,789 --> 00:20:56,640
the recent greaves at all 2022 upper

576
00:21:00,310 --> 00:20:58,799
limits are valid then it's not so2 is it

577
00:21:01,350 --> 00:21:00,320
a third molecule is it something else

578
00:21:04,230 --> 00:21:01,360
entirely

579
00:21:06,789 --> 00:21:04,240
on novel photochemistry we're not sure

580
00:21:08,070 --> 00:21:06,799
the final kind of argument for what a

581
00:21:09,510 --> 00:21:08,080
kind of line of evidence for is

582
00:21:11,590 --> 00:21:09,520
phosphorus and phosphine present on

583
00:21:13,830 --> 00:21:11,600
venus comes from the pioneer venus which

584
00:21:15,590 --> 00:21:13,840
the previous speaker kind of alluded to

585
00:21:17,029 --> 00:21:15,600
the idea there is that if you go back

586
00:21:18,789 --> 00:21:17,039
and look at the

587
00:21:21,590 --> 00:21:18,799
mass spec data from the pioneer venus in

588
00:21:23,750 --> 00:21:21,600

situ mission you find evidence for

589
00:21:25,110 --> 00:21:23,760
the various equilibrium species

590
00:21:26,950 --> 00:21:25,120
including tentative evidence for

591
00:21:28,549 --> 00:21:26,960
phosphine the

592
00:21:29,990 --> 00:21:28,559
author of this work rakesh mogul is

593
00:21:31,430 --> 00:21:30,000
actually here so if you have questions

594
00:21:33,270 --> 00:21:31,440
about this i recommend you ask him or

595
00:21:35,510 --> 00:21:33,280
look at his poster i'll summarize his

596
00:21:37,510 --> 00:21:35,520
arguments very briefly he robustly

597
00:21:40,230 --> 00:21:37,520
detects his main argument is predicated

598
00:21:42,149 --> 00:21:40,240
on detection of this p-plus he robustly

599
00:21:43,590 --> 00:21:42,159
deducts p-plus he asks what are the

600
00:21:45,270 --> 00:21:43,600
possible parent gases given the

601
00:21:47,430 --> 00:21:45,280
temperature pressure conditions in the

602
00:21:48,789 --> 00:21:47,440
venous clouds and he finds that of those

603
00:21:51,430 --> 00:21:48,799
the ones that are most cons that are

604
00:21:52,710 --> 00:21:51,440
allowed by his analysis the data only ph

605
00:21:55,270 --> 00:21:52,720
three fifths

606
00:21:57,669 --> 00:21:55,280
the second argument is a little bit much

607
00:22:01,029 --> 00:21:57,679
less certain uh he specifically looks at

608
00:22:03,029 --> 00:22:01,039
the 34 amu channel and asks uh hey do

609
00:22:04,390 --> 00:22:03,039
you see evidence of p3 there this is

610
00:22:06,390 --> 00:22:04,400
much more tentative because there's

611
00:22:08,070 --> 00:22:06,400
multiple species that are present there

612
00:22:10,950 --> 00:22:08,080
overall he finds that his fit slightly

613
00:22:12,549 --> 00:22:10,960

prefer h2s and ph3 but he's uh that's a

614
00:22:13,909 --> 00:22:12,559
little that's a little bit less

615
00:22:15,990 --> 00:22:13,919
assertive

616
00:22:17,430 --> 00:22:16,000
uh there's no other independent analysis

617
00:22:18,789 --> 00:22:17,440
of these data so far but i know that

618
00:22:20,230 --> 00:22:18,799
there's groups working on this so i

619
00:22:22,230 --> 00:22:20,240
reached out to them to ask if they might

620
00:22:25,190 --> 00:22:22,240
have comments so the work i'll share

621
00:22:26,549 --> 00:22:25,200
with you now is in prep so uh please

622
00:22:28,710 --> 00:22:26,559
take it

623
00:22:31,430 --> 00:22:28,720
and treat it appropriately

624
00:22:33,029 --> 00:22:31,440
but so overall will brinkerhoff over at

625
00:22:35,909 --> 00:22:33,039
nasa goddard is leading an independent

626
00:22:37,270 --> 00:22:35,919
analysis of these data uh he does detect

627
00:22:39,190 --> 00:22:37,280
phosphorus species present in the

628
00:22:40,630 --> 00:22:39,200
atmosphere of venus but the data

629
00:22:43,110 --> 00:22:40,640
analysis is extremely challenging and

630
00:22:46,070 --> 00:22:43,120
he's not able to either affirm or deny

631
00:22:47,990 --> 00:22:46,080
the results of mogul at all at this time

632
00:22:49,990 --> 00:22:48,000
michael radke over at johns hopkins is

633
00:22:51,909 --> 00:22:50,000
also leading an analysis of this data

634
00:22:54,630 --> 00:22:51,919
and he's focused on the 34 amu mass

635
00:22:57,990 --> 00:22:54,640
channel for this mass channel he finds

636
00:23:00,149 --> 00:22:58,000
that either h2s or ph3 plus h2s can

637
00:23:02,070 --> 00:23:00,159
explain the observed ph

638
00:23:04,630 --> 00:23:02,080

complain the observed signal

639
00:23:05,909 --> 00:23:04,640
overall all groups agree that this is a

640
00:23:08,230 --> 00:23:05,919
data are hard to interpret better

641
00:23:09,830 --> 00:23:08,240
measurements are essential and from that

642
00:23:11,909 --> 00:23:09,840
perspective upcoming mentions like

643
00:23:14,230 --> 00:23:11,919
davinci are going to be really exciting

644
00:23:16,390 --> 00:23:14,240
to summarize the key takeaways phosphine

645
00:23:18,070 --> 00:23:16,400
at present on venus is very very weird

646
00:23:19,510 --> 00:23:18,080
and we don't i don't think it's possible

647
00:23:20,710 --> 00:23:19,520
to explain with our conventional picture

648
00:23:23,270 --> 00:23:20,720
of phosphine and our conventional

649
00:23:25,029 --> 00:23:23,280
picture of venus observations and lab

650
00:23:26,789 --> 00:23:25,039
measurements are required to confirm

651
00:23:28,789 --> 00:23:26,799
whether or not ph3 is really present on

652
00:23:31,110 --> 00:23:28,799
venus and if it's there to confirm

653
00:23:33,110 --> 00:23:31,120
constrain possible formation mechanisms

654
00:23:35,350 --> 00:23:33,120
one surprising takeaway for me as i was

655
00:23:36,950 --> 00:23:35,360
working on this project is how little we

656
00:23:38,630 --> 00:23:36,960
understand about our nearest neighbor

657
00:23:39,909 --> 00:23:38,640
from that perspective i think upcoming

658
00:23:41,029 --> 00:23:39,919
missions are coming at a really good

659
00:23:42,789 --> 00:23:41,039
time

660
00:23:44,390 --> 00:23:42,799
one thing it's also worth commenting on

661
00:23:46,310 --> 00:23:44,400
is that one reason for the excitement

662
00:23:47,990 --> 00:23:46,320
about ph3 in particular was its

663
00:23:49,990 --> 00:23:48,000

association with biological production

664
00:23:52,230 --> 00:23:50,000
here on earth so the question could it

665
00:23:53,750 --> 00:23:52,240
potentially be a bioindicator

666
00:23:55,269 --> 00:23:53,760
for that i kind of stand by what we

667
00:23:56,630 --> 00:23:55,279
wrote in our original paper which is

668
00:23:58,470 --> 00:23:56,640
before we can start entertaining

669
00:24:00,390 --> 00:23:58,480
questions about a biological origin

670
00:24:02,390 --> 00:24:00,400
first we need to nail the basics is it

671
00:24:04,470 --> 00:24:02,400
actually there and can mechanisms we

672
00:24:06,310 --> 00:24:04,480
know about explain it and that's kind of

673
00:24:07,460 --> 00:24:06,320
where i stand today thanks so much for

674
00:24:14,390 --> 00:24:07,470
your time

675
00:24:17,510 --> 00:24:16,149
thanks super for a really wonderful

676
00:24:20,310 --> 00:24:17,520
overview

677
00:24:22,630 --> 00:24:20,320
and so continuing on

678
00:24:25,190 --> 00:24:22,640
the phosphine theme our next speaker is

679
00:24:27,350 --> 00:24:25,200
eddie swederman from uc riverside

680
00:24:29,350 --> 00:24:27,360
who will speak on in uncertainties in

681
00:24:34,390 --> 00:24:29,360
the detection of venus phosphine and its

682
00:24:37,430 --> 00:24:36,549
yeah thank you very much tim

683
00:24:39,909 --> 00:24:37,440
um

684
00:24:41,990 --> 00:24:39,919
so this is a topic uh a lot of people

685
00:24:42,870 --> 00:24:42,000
have a lot of opinions about

686
00:24:45,269 --> 00:24:42,880
um

687
00:24:48,230 --> 00:24:45,279
and not and i don't have a lot of time

688
00:24:50,470 --> 00:24:48,240

so if you know something really crucial

689
00:24:51,830 --> 00:24:50,480
and important and i forgot to put it in

690
00:24:53,830 --> 00:24:51,840
i didn't forget to put it in i just

691
00:24:56,470 --> 00:24:53,840
didn't have the time to say it

692
00:24:59,029 --> 00:24:56,480
but if i were to

693
00:25:00,630 --> 00:24:59,039
think about how to frame this debate

694
00:25:04,230 --> 00:25:00,640
i would break down

695
00:25:06,630 --> 00:25:04,240
these steps is there phosphene on venus

696
00:25:08,630 --> 00:25:06,640
steps one two here and is it due to life

697
00:25:11,029 --> 00:25:08,640
now is it due to life is not to say that

698
00:25:13,990 --> 00:25:11,039
the everyone who claims that phosphine

699
00:25:16,710 --> 00:25:14,000
on venus uh is claiming that it's due to

700
00:25:18,710 --> 00:25:16,720
life it's more that it's been claimed

701
00:25:21,590 --> 00:25:18,720
that this could be an explanation if all

702
00:25:23,909 --> 00:25:21,600
other abiotic uh sources are ruled out

703
00:25:26,230 --> 00:25:23,919
and moreover phosphine has been proposed

704
00:25:29,110 --> 00:25:26,240
as an exoplanet biosignature

705
00:25:30,870 --> 00:25:29,120
um and so we really need to understand

706
00:25:33,110 --> 00:25:30,880
if this gas can build up in terrestrial

707
00:25:35,669 --> 00:25:33,120
planet atmospheres in our solar system

708
00:25:38,549 --> 00:25:35,679
abiotically if we're going to assign

709
00:25:40,230 --> 00:25:38,559
biogenicity to a remote observation

710
00:25:42,950 --> 00:25:40,240
and so if we were to really treat all of

711
00:25:45,110 --> 00:25:42,960
these questions uh in due course

712
00:25:47,350 --> 00:25:45,120
uh and go into depth we'd probably be

713
00:25:49,110 --> 00:25:47,360

here for about six months and celebrate

714
00:25:51,590 --> 00:25:49,120
new year's together

715
00:25:54,549 --> 00:25:51,600
um but it's really important

716
00:25:56,870 --> 00:25:54,559
because if we ever hope to find life for

717
00:25:59,830 --> 00:25:56,880
example on an exoplanet we will have to

718
00:26:02,630 --> 00:25:59,840
resolve this venus phosphine debate

719
00:26:04,710 --> 00:26:02,640
exoplanets are kind of like the remote

720
00:26:06,710 --> 00:26:04,720
online only sessions

721
00:26:10,630 --> 00:26:06,720
of the conference you know you can only

722
00:26:14,470 --> 00:26:12,549
um

723
00:26:16,549 --> 00:26:14,480
whereas venus is the hybrid oral session

724
00:26:19,430 --> 00:26:16,559
the best of both worlds so you can get

725
00:26:21,990 --> 00:26:19,440
the remote data and the in-situ data and

726
00:26:23,669 --> 00:26:22,000
so we will know whether phosphine is on

727
00:26:25,350 --> 00:26:23,679
venus and we will eventually know how

728
00:26:26,950 --> 00:26:25,360
it's made

729
00:26:28,230 --> 00:26:26,960
um and so this is really going to help

730
00:26:29,830 --> 00:26:28,240
us in

731
00:26:32,390 --> 00:26:29,840
advancing our understanding of remote

732
00:26:34,950 --> 00:26:32,400
bios signatures so i want to

733
00:26:36,950 --> 00:26:34,960
just expand a little bit on what sucret

734
00:26:38,950 --> 00:26:36,960
said to show some visuals that will

735
00:26:41,830 --> 00:26:38,960
enhance uh maybe maybe some of his

736
00:26:46,070 --> 00:26:41,840
summary which is that why do we why did

737
00:26:48,149 --> 00:26:46,080
we uh claim phosphine is on venus

738
00:26:49,430 --> 00:26:48,159

there were two observatories

739
00:26:55,190 --> 00:26:49,440
that

740
00:26:59,590 --> 00:26:55,200
interpreted as showing phosphine at this

741
00:27:00,390 --> 00:26:59,600
1.11 millimeter line 266.94 gigahertz

742
00:27:01,830 --> 00:27:00,400
and

743
00:27:04,149 --> 00:27:01,840
in principle this is really good these

744
00:27:06,390 --> 00:27:04,159
are two independent observatories

745
00:27:08,710 --> 00:27:06,400
so you can sort of rule out systematics

746
00:27:11,430 --> 00:27:08,720
that's good that's that's step one

747
00:27:12,870 --> 00:27:11,440
um and not only that

748
00:27:15,190 --> 00:27:12,880
um

749
00:27:17,909 --> 00:27:15,200
so so the the the phosphine that was

750
00:27:19,269 --> 00:27:17,919
there was assumed to be above the clouds

751
00:27:21,430 --> 00:27:19,279
um

752
00:27:23,590 --> 00:27:21,440
backlit backlit by the thermal emission

753
00:27:25,190 --> 00:27:23,600
from the clouds and this is important

754
00:27:27,590 --> 00:27:25,200
for interpretations that involve life

755
00:27:29,350 --> 00:27:27,600
because the clouds as candy mentioned

756
00:27:31,029 --> 00:27:29,360
were potentially the most clement place

757
00:27:33,430 --> 00:27:31,039
on venus

758
00:27:35,830 --> 00:27:33,440
so the complication is that there is a

759
00:27:38,470 --> 00:27:35,840
competing absorber where phosphine

760
00:27:41,110 --> 00:27:38,480
absorbs so sulfur dioxide has a very

761
00:27:42,549 --> 00:27:41,120
very proximal absorption line

762
00:27:44,149 --> 00:27:42,559
the authors of the original study

763
00:27:44,950 --> 00:27:44,159

grieves at all were very well aware of

764
00:27:48,549 --> 00:27:44,960
this

765
00:27:50,870 --> 00:27:48,559
and so looked for that line

766
00:27:52,549 --> 00:27:50,880
in a at a reference wavelength so not

767
00:27:53,750 --> 00:27:52,559
the wavelength where phosphine absorbs

768
00:27:55,750 --> 00:27:53,760
but a separate

769
00:27:57,669 --> 00:27:55,760
sulfur dioxide wavelength where there is

770
00:27:58,710 --> 00:27:57,679
no phosphine absorption

771
00:28:01,830 --> 00:27:58,720
and so

772
00:28:05,190 --> 00:28:01,840
with no sulfur dioxide detected

773
00:28:07,350 --> 00:28:05,200
suggesting a upper limit of 10 ppb

774
00:28:08,230 --> 00:28:07,360
on sulfur dioxide they could then fold

775
00:28:10,710 --> 00:28:08,240
that

776
00:28:12,950 --> 00:28:10,720
inferred absorption property of sulfur

777
00:28:14,870 --> 00:28:12,960
dioxide at the phosphine line

778
00:28:16,710 --> 00:28:14,880
and and

779
00:28:19,350 --> 00:28:16,720
calculate that the contribution would be

780
00:28:21,909 --> 00:28:19,360
less than ten percent

781
00:28:23,230 --> 00:28:21,919
now importantly this uh sulfur dioxide

782
00:28:25,990 --> 00:28:23,240
observation was not made

783
00:28:27,990 --> 00:28:26,000
contemporaneously with the phosphine

784
00:28:29,269 --> 00:28:28,000
observation and that will come into play

785
00:28:30,710 --> 00:28:29,279
later

786
00:28:33,269 --> 00:28:30,720
and so there are some summaries i mean

787
00:28:35,110 --> 00:28:33,279
the secret went through this um but

788
00:28:37,190 --> 00:28:35,120

just to break it down again

789
00:28:39,430 --> 00:28:37,200
the initial critical papers had sort of

790
00:28:42,310 --> 00:28:39,440
two flavors flavor one is that the

791
00:28:45,990 --> 00:28:42,320
signal can't be recovered at all uh due

792
00:28:48,230 --> 00:28:46,000
to spurious uh uh experience due to you

793
00:28:49,110 --> 00:28:48,240
know uh the methods of analyzing the

794
00:28:51,909 --> 00:28:49,120
data

795
00:28:54,630 --> 00:28:51,919
such as polynomial overfitting

796
00:28:57,669 --> 00:28:54,640
or that the signal is detected such as

797
00:28:59,830 --> 00:28:57,679
the signal from jcmt but it's actually

798
00:29:01,590 --> 00:28:59,840
due to so2 and misattributed to

799
00:29:03,269 --> 00:29:01,600
phosphine now importantly the grieves

800
00:29:08,070 --> 00:29:03,279
that all team released their data upon

801
00:29:12,710 --> 00:29:09,750
investigators could look at that data

802
00:29:14,630 --> 00:29:12,720
quickly

803
00:29:16,630 --> 00:29:14,640
the team responded

804
00:29:18,630 --> 00:29:16,640
by reanalyzing their data

805
00:29:20,070 --> 00:29:18,640
and doing statistical tests and they

806
00:29:22,710 --> 00:29:20,080
could not produce

807
00:29:25,830 --> 00:29:22,720
these spurious lines they then looked

808
00:29:28,149 --> 00:29:25,840
for another molecule that has a similar

809
00:29:30,230 --> 00:29:28,159
absorption property hdo and found that

810
00:29:33,029 --> 00:29:30,240
robustly with the same method

811
00:29:34,950 --> 00:29:33,039
and they absorbed observed the so2

812
00:29:36,789 --> 00:29:34,960
reference line

813
00:29:38,310 --> 00:29:36,799

again and could not

814
00:29:40,789 --> 00:29:38,320
uh uh

815
00:29:42,470 --> 00:29:40,799
allow that that that that

816
00:29:45,269 --> 00:29:42,480
inferred abundance would not produce the

817
00:29:46,710 --> 00:29:45,279
phosphine absorption

818
00:29:48,870 --> 00:29:46,720
so i'm just going to say i'm just going

819
00:29:50,789 --> 00:29:48,880
to go through the most salient sort of

820
00:29:52,630 --> 00:29:50,799
uh paradox here

821
00:29:54,549 --> 00:29:52,640
which is that if

822
00:29:55,830 --> 00:29:54,559
there is absorb if there is absorption

823
00:29:58,310 --> 00:29:55,840
in this line

824
00:30:00,149 --> 00:29:58,320
with radio transfer modeling it appears

825
00:30:03,510 --> 00:30:00,159
that this line is coming from the

826
00:30:05,510 --> 00:30:03,520
mesosphere so above 80 kilometers

827
00:30:06,830 --> 00:30:05,520
and the problem with that if uh we're

828
00:30:08,870 --> 00:30:06,840
going through the phosphine

829
00:30:11,430 --> 00:30:08,880
interpretation is that the photochemical

830
00:30:14,710 --> 00:30:11,440
lifetimes at these altitudes are very

831
00:30:17,430 --> 00:30:14,720
very uh low so less than a second

832
00:30:19,110 --> 00:30:17,440
at 80 kilometers

833
00:30:22,070 --> 00:30:19,120
and so that would infer a production

834
00:30:24,470 --> 00:30:22,080
flux that is enormous so you know many

835
00:30:26,149 --> 00:30:24,480
times the rate of oxygen production

836
00:30:28,149 --> 00:30:26,159
on earth

837
00:30:29,750 --> 00:30:28,159
moreover if you assume the phosphine is

838
00:30:32,149 --> 00:30:29,760

only in the clouds you don't get a

839
00:30:34,230 --> 00:30:32,159
detectable signal

840
00:30:35,830 --> 00:30:34,240
so linkowski at all uh

841
00:30:39,190 --> 00:30:35,840
instead argued that the signal is

842
00:30:41,990 --> 00:30:39,200
attributable to sulfur dioxide and they

843
00:30:44,149 --> 00:30:42,000
assume a profile um from sulfur dioxide

844
00:30:46,149 --> 00:30:44,159
that's statistically high but within

845
00:30:48,310 --> 00:30:46,159
the bounds of the original

846
00:30:50,230 --> 00:30:48,320
of past observations

847
00:30:52,789 --> 00:30:50,240
and so this is acknowledged by the

848
00:30:55,029 --> 00:30:52,799
phosphine detection team that this is a

849
00:30:56,870 --> 00:30:55,039
this is a problem and that the phosphine

850
00:30:57,750 --> 00:30:56,880
should rapidly dissociate

851
00:30:59,750 --> 00:30:57,760
the

852
00:31:00,870 --> 00:30:59,760
caveat here is that this requires high

853
00:31:03,029 --> 00:31:00,880
so2

854
00:31:06,870 --> 00:31:03,039
and that the team has gone back agrees

855
00:31:08,549 --> 00:31:06,880
at all and found public jc mt data just

856
00:31:10,310 --> 00:31:08,559
a few days before those phosphine

857
00:31:12,149 --> 00:31:10,320
observations

858
00:31:15,909 --> 00:31:12,159
and um

859
00:31:17,750 --> 00:31:15,919
also recover below pp 10 ppb

860
00:31:20,389 --> 00:31:17,760
concentrations of sulfur dioxide it's

861
00:31:21,830 --> 00:31:20,399
not enough to explain the line and so in

862
00:31:24,630 --> 00:31:21,840
order to explain this with sulfur

863
00:31:25,990 --> 00:31:24,640

dioxide we would have to invoke temporal

864
00:31:29,750 --> 00:31:26,000
variability

865
00:31:31,669 --> 00:31:29,760
bounds of reference measurements and

866
00:31:33,669 --> 00:31:31,679
modeling but we can't be sure until we

867
00:31:34,950 --> 00:31:33,679
can actually measure it simultaneously

868
00:31:37,590 --> 00:31:34,960
so the gold standard here will be

869
00:31:40,549 --> 00:31:37,600
simultaneous reference measurements of

870
00:31:43,669 --> 00:31:40,559
so2 plus phosphine or measurements of a

871
00:31:46,630 --> 00:31:43,679
clean phosphine line or in situ and

872
00:31:49,509 --> 00:31:46,640
preferably and in situ measurements

873
00:31:51,110 --> 00:31:49,519
so there's supporting evidence and

874
00:31:53,029 --> 00:31:51,120
non-supporting evidence for phosphine

875
00:31:55,830 --> 00:31:53,039
independently supporting evidence as

876
00:31:58,389 --> 00:31:55,840
secret mentioned uh from re-analysis of

877
00:31:59,990 --> 00:31:58,399
pioneer venus massback non-supporting

878
00:32:01,269 --> 00:32:00,000
evidence of near

879
00:32:02,789 --> 00:32:01,279
infrared

880
00:32:06,389 --> 00:32:02,799
complementary absorption features of

881
00:32:08,789 --> 00:32:06,399
phosphine where upper limits are

882
00:32:11,750 --> 00:32:08,799
are given which seem

883
00:32:13,590 --> 00:32:11,760
low compared to the claim detection

884
00:32:15,350 --> 00:32:13,600
concentrations

885
00:32:17,269 --> 00:32:15,360
and then finally there's a biological

886
00:32:19,430 --> 00:32:17,279
implausibility argument

887
00:32:21,350 --> 00:32:19,440
going back not just to the detection of

888
00:32:22,870 --> 00:32:21,360

phosphine but the idea that it's due to

889
00:32:24,630 --> 00:32:22,880
life

890
00:32:26,950 --> 00:32:24,640
is that as several papers have

891
00:32:28,549 --> 00:32:26,960
acknowledged the water activity is

892
00:32:30,789 --> 00:32:28,559
really really low so it's not just a ph

893
00:32:33,269 --> 00:32:30,799
it's the water activity and here's a

894
00:32:34,549 --> 00:32:33,279
plot from halsworth at all that shows

895
00:32:35,830 --> 00:32:34,559
the water activity as a function of

896
00:32:38,789 --> 00:32:35,840
temperature and sulfuric acid

897
00:32:41,110 --> 00:32:38,799
concentration and the gray uh the black

898
00:32:43,750 --> 00:32:41,120
line is the lowest water activity for

899
00:32:45,350 --> 00:32:43,760
earth life the gray line is the water

900
00:32:47,269 --> 00:32:45,360
activity

901
00:32:48,630 --> 00:32:47,279
predicted for venus

902
00:32:51,350 --> 00:32:48,640
and it's two orders of magnitude

903
00:32:53,110 --> 00:32:51,360
different so this is a real big problem

904
00:32:54,870 --> 00:32:53,120
unless our understanding of venous

905
00:32:56,070 --> 00:32:54,880
environments are wrong i don't have

906
00:32:57,269 --> 00:32:56,080
enough time to go through these papers

907
00:32:58,630 --> 00:32:57,279
but that's a suggestion that our

908
00:33:00,230 --> 00:32:58,640
understanding of those environments are

909
00:33:03,029 --> 00:33:00,240
wrong and that could impact

910
00:33:05,190 --> 00:33:03,039
um the inferred water activity

911
00:33:06,630 --> 00:33:05,200
and then finally there's the biological

912
00:33:10,710 --> 00:33:06,640
possibility argument of why make

913
00:33:11,909 --> 00:33:10,720

phosphine so phosphine uh is the release

914
00:33:13,990 --> 00:33:11,919
of hydrogen

915
00:33:15,750 --> 00:33:14,000
and and electrons which are very very

916
00:33:17,590 --> 00:33:15,760
scarce in the oxidizing environment of

917
00:33:19,830 --> 00:33:17,600
venus and so

918
00:33:21,509 --> 00:33:19,840
why would you do that so to summarize

919
00:33:24,389 --> 00:33:21,519
this slide um

920
00:33:27,990 --> 00:33:24,399
was the signal detected it seems likely

921
00:33:29,830 --> 00:33:28,000
the remaining arguments are not proven

922
00:33:31,669 --> 00:33:29,840
but there are you know competing

923
00:33:33,110 --> 00:33:31,679
hypotheses

924
00:33:34,789 --> 00:33:33,120
and so

925
00:33:37,909 --> 00:33:34,799
with that i'm going to end

926
00:33:38,950 --> 00:33:37,919
my talk and think uh very deeply um my

927
00:33:41,590 --> 00:33:38,960
colleagues

928
00:33:43,190 --> 00:33:41,600
and uh of course any mistakes were mined

929
00:33:50,870 --> 00:33:43,200
so thank you

930
00:33:50,880 --> 00:33:56,789
thanks very much eddie

931
00:34:00,950 --> 00:33:58,549
so we're going to take the implications

932
00:34:03,669 --> 00:34:00,960
of venus science beyond our solar system

933
00:34:05,190 --> 00:34:03,679
and stephen kane from uc riverside

934
00:34:07,269 --> 00:34:05,200
is going to talk to us about venus

935
00:34:16,950 --> 00:34:07,279
within the context of exoplanets and

936
00:34:20,310 --> 00:34:18,310
thank you tim

937
00:34:22,550 --> 00:34:20,320
and uh

938
00:34:24,470 --> 00:34:22,560

thank you to all of you here and online

939
00:34:26,230 --> 00:34:24,480
for coming to the uh early morning

940
00:34:28,710 --> 00:34:26,240
session on the last day of the meeting

941
00:34:30,470 --> 00:34:28,720
uh so uh as tim mentioned i'm going to

942
00:34:33,109 --> 00:34:30,480
be talking about venus in the context of

943
00:34:36,310 --> 00:34:33,119
exoplanets and and habitability

944
00:34:38,230 --> 00:34:36,320
uh so uh this uh this title

945
00:34:39,990 --> 00:34:38,240
slide is showing uh one of the glorious

946
00:34:40,950 --> 00:34:40,000
pictures from the japanese akatsuki

947
00:34:43,430 --> 00:34:40,960
mission

948
00:34:46,470 --> 00:34:43,440
alongside an artist's depiction of what

949
00:34:48,550 --> 00:34:46,480
venus may have looked like as recently

950
00:34:51,270 --> 00:34:48,560
as one to two giga years ago

951
00:34:53,270 --> 00:34:51,280
and this is a fundamental question uh

952
00:34:55,430 --> 00:34:53,280
that uh that candice mentioned earlier

953
00:34:57,349 --> 00:34:55,440
that we uh that we need to figure out

954
00:34:59,030 --> 00:34:57,359
but uh there are several pathways to do

955
00:35:01,589 --> 00:34:59,040
this one is venus intrinsically and the

956
00:35:02,390 --> 00:35:01,599
other is uh looking at the statistical

957
00:35:05,030 --> 00:35:02,400
power

958
00:35:06,550 --> 00:35:05,040
of many many potential venus analogues

959
00:35:08,150 --> 00:35:06,560
uh so

960
00:35:10,390 --> 00:35:08,160
many of you are probably aware that we

961
00:35:12,230 --> 00:35:10,400
have recently crossed a significant

962
00:35:14,790 --> 00:35:12,240
boundary in the in the exoplanet

963
00:35:16,310 --> 00:35:14,800

detection uh parameter space and we've

964
00:35:18,470 --> 00:35:16,320
uh we've crossed the boundary five

965
00:35:20,710 --> 00:35:18,480
thousand uh more than five thousand

966
00:35:22,550 --> 00:35:20,720
exoplanets uh most of which have been

967
00:35:24,310 --> 00:35:22,560
found through radial velocity and

968
00:35:26,630 --> 00:35:24,320
transit method which are heavily biased

969
00:35:29,670 --> 00:35:26,640
towards planets which are closer to

970
00:35:31,670 --> 00:35:29,680
their host stars and the deep dive into

971
00:35:33,349 --> 00:35:31,680
the terrestrial regime really came

972
00:35:36,310 --> 00:35:33,359
through the kepler mission and this is a

973
00:35:39,030 --> 00:35:36,320
famous uh plot which summarizes much of

974
00:35:41,349 --> 00:35:39,040
the results of the kepler mission uh

975
00:35:43,190 --> 00:35:41,359
showing the radius and the orbital

976
00:35:45,589 --> 00:35:43,200
period distribution of the candidates

977
00:35:47,910 --> 00:35:45,599
that were found thousands of candidates

978
00:35:50,069 --> 00:35:47,920
found with the kepler mission and

979
00:35:52,390 --> 00:35:50,079
eagle-eyed people will notice that i've

980
00:35:54,470 --> 00:35:52,400
made a slight modification to this

981
00:35:59,190 --> 00:35:54,480
figure because i'm showing the size

982
00:36:00,950 --> 00:35:59,200
relative to venus uh the main purpose of

983
00:36:04,310 --> 00:36:00,960
kepler that was highlighted was

984
00:36:06,390 --> 00:36:04,320
determining the current rate of earth

985
00:36:08,870 --> 00:36:06,400
analogues but if you're looking for a

986
00:36:10,550 --> 00:36:08,880
size planets you're going to find uh

987
00:36:12,790 --> 00:36:10,560
many of the venus sized planets along

988
00:36:15,030 --> 00:36:12,800

the way and i've

989
00:36:17,349 --> 00:36:15,040
also shown there are standard units of

990
00:36:20,390 --> 00:36:17,359
size measurement jupiter neptune and of

991
00:36:21,990 --> 00:36:20,400
course venus so one of the main results

992
00:36:25,349 --> 00:36:22,000
to come out of the kepler mission was

993
00:36:27,750 --> 00:36:25,359
showing that the the distribution of

994
00:36:30,230 --> 00:36:27,760
planets increases towards smaller sizes

995
00:36:31,670 --> 00:36:30,240
that there are many more smaller planets

996
00:36:34,150 --> 00:36:31,680
than there are

997
00:36:36,390 --> 00:36:34,160
larger planets and because of the bias i

998
00:36:38,470 --> 00:36:36,400
mentioned earlier i frequently referred

999
00:36:41,589 --> 00:36:38,480
to kepler as a mean lean venus finding

1000
00:36:45,030 --> 00:36:41,599
machine which indeed it was it found

1001
00:36:47,750 --> 00:36:45,040
many of these kinds of uh of planets

1002
00:36:49,990 --> 00:36:47,760
that could potentially be analogues

1003
00:36:52,230 --> 00:36:50,000
so i had worked

1004
00:36:55,190 --> 00:36:52,240
with uh with my colleagues ravi

1005
00:36:58,550 --> 00:36:55,200
kopperapu and sean domingo goldman to

1006
00:37:01,190 --> 00:36:58,560
try and quantify the occurrence rates of

1007
00:37:02,710 --> 00:37:01,200
what those kinds of planets are that are

1008
00:37:04,390 --> 00:37:02,720
the the planets which may have been

1009
00:37:06,470 --> 00:37:04,400
pushed into a post-runaway greenhouse

1010
00:37:08,470 --> 00:37:06,480
state and of course we call this the

1011
00:37:11,270 --> 00:37:08,480
venus zone rather than the hubble zone

1012
00:37:12,790 --> 00:37:11,280
and we had many more uh planets to put

1013
00:37:14,550 --> 00:37:12,800

into this region because of that

1014
00:37:15,589 --> 00:37:14,560
selection bias of the observing

1015
00:37:18,390 --> 00:37:15,599
technique

1016
00:37:21,109 --> 00:37:18,400
and so we calculated that from the

1017
00:37:24,150 --> 00:37:21,119
results from the kepler mission

1018
00:37:26,790 --> 00:37:24,160
that uh for m stars we had an occurrence

1019
00:37:28,069 --> 00:37:26,800
rate of about 32 with a with a potential

1020
00:37:30,790 --> 00:37:28,079
venus analog

1021
00:37:34,150 --> 00:37:30,800
and for more solar type stars g's and

1022
00:37:35,510 --> 00:37:34,160
k's it was closer to 45 and so this was

1023
00:37:37,589 --> 00:37:35,520
starting to tell us something very

1024
00:37:41,270 --> 00:37:37,599
significant that potential venous

1025
00:37:42,790 --> 00:37:41,280
analogues may be extremely common and

1026
00:37:45,829 --> 00:37:42,800
this is going to be something that is

1027
00:37:48,390 --> 00:37:45,839
going to contribute heavily towards this

1028
00:37:50,710 --> 00:37:48,400
discussion about the evolutionary

1029
00:37:53,510 --> 00:37:50,720
pathways of venus relative to earth in

1030
00:37:55,829 --> 00:37:53,520
the coming years uh i also encourage you

1031
00:37:57,430 --> 00:37:55,839
to check out a recent paper by monica

1032
00:38:00,310 --> 00:37:57,440
vidari who

1033
00:38:03,349 --> 00:38:00,320
who published a paper about an update to

1034
00:38:06,950 --> 00:38:05,190
well this legacy is being continued

1035
00:38:10,310 --> 00:38:06,960
right now we of course have the

1036
00:38:13,829 --> 00:38:10,320
transient exoplanet survey satellite uh

1037
00:38:15,910 --> 00:38:13,839
and uh this uh is a very significant

1038
00:38:17,270 --> 00:38:15,920

step towards this characterization of

1039
00:38:19,750 --> 00:38:17,280
venus analogs because it's

1040
00:38:21,670 --> 00:38:19,760
preferentially finding transiting

1041
00:38:24,630 --> 00:38:21,680
planets around bright host stars and

1042
00:38:26,630 --> 00:38:24,640
these will be our prime candidates for

1043
00:38:29,990 --> 00:38:26,640
atmospheric follow-up with james webb

1044
00:38:33,109 --> 00:38:30,000
and other facilities into the future so

1045
00:38:35,190 --> 00:38:33,119
from the from the early sectors uh

1046
00:38:37,190 --> 00:38:35,200
colby osberg and myself looked at the

1047
00:38:39,270 --> 00:38:37,200
number of candidates and and produced a

1048
00:38:40,790 --> 00:38:39,280
catalogue uh of the candidates that was

1049
00:38:43,589 --> 00:38:40,800
just from the first year of the mission

1050
00:38:47,030 --> 00:38:43,599
sectors 1-13 we're now well into the

1051
00:38:49,510 --> 00:38:47,040
extended period of the test mission uh i

1052
00:38:52,390 --> 00:38:49,520
believe we're at sector 51 transitioning

1053
00:38:55,349 --> 00:38:52,400
over into sector 52 and there are many

1054
00:38:57,270 --> 00:38:55,359
many more of these candidates uh meaning

1055
00:38:59,910 --> 00:38:57,280
planets which are likely terrestrial

1056
00:39:02,630 --> 00:38:59,920
that are orbiting uh bright host stars

1057
00:39:05,430 --> 00:39:02,640
so there are many more possibilities

1058
00:39:08,150 --> 00:39:05,440
coming down the pipe

1059
00:39:10,790 --> 00:39:08,160
so uh one of the main challenges as i

1060
00:39:12,829 --> 00:39:10,800
said is well then what do we do

1061
00:39:15,510 --> 00:39:12,839
with uh with all of

1062
00:39:18,230 --> 00:39:15,520
these potential venus analogues which

1063
00:39:21,349 --> 00:39:18,240

are orbiting bright host stars uh

1064
00:39:23,910 --> 00:39:21,359
because part of the debate is is that

1065
00:39:25,510 --> 00:39:23,920
well we don't know if venus was always

1066
00:39:28,550 --> 00:39:25,520
in this state or if there was a

1067
00:39:32,550 --> 00:39:28,560
transitionary period and so atmospheric

1068
00:39:35,349 --> 00:39:32,560
characterization will be part of the the

1069
00:39:37,670 --> 00:39:35,359
process that we'll go through here but

1070
00:39:40,150 --> 00:39:37,680
what many of us are looking at now is

1071
00:39:43,349 --> 00:39:40,160
how do we actually distinguish between

1072
00:39:46,470 --> 00:39:43,359
venus and earth analogs when we are

1073
00:39:48,630 --> 00:39:46,480
producing uh transmission spectroscopy

1074
00:39:51,589 --> 00:39:48,640
of the upper layers of the atmosphere

1075
00:39:54,790 --> 00:39:51,599
we're getting us only a slight preview

1076
00:39:57,349 --> 00:39:54,800
into what the full atmosphere looks like

1077
00:39:58,630 --> 00:39:57,359
and the the challenge is to take what we

1078
00:40:01,270 --> 00:39:58,640
measure from the very top of the

1079
00:40:03,510 --> 00:40:01,280
atmosphere and extrapolate that all the

1080
00:40:06,390 --> 00:40:03,520
way down to the surface that's not an

1081
00:40:08,630 --> 00:40:06,400
easy thing to do particularly with venus

1082
00:40:09,750 --> 00:40:08,640
having so many missing pieces in our

1083
00:40:12,230 --> 00:40:09,760
knowledge

1084
00:40:14,790 --> 00:40:12,240
for the middle and the deep parts of the

1085
00:40:17,109 --> 00:40:14,800
atmosphere and so what's really required

1086
00:40:19,670 --> 00:40:17,119
is detailed pressure temperature

1087
00:40:22,390 --> 00:40:19,680
composition and chemistry

1088
00:40:25,589 --> 00:40:22,400

profiles with altitude and how they're

1089
00:40:28,470 --> 00:40:25,599
varying with other planetary properties

1090
00:40:30,630 --> 00:40:28,480
such as mass radius insulation flux

1091
00:40:33,190 --> 00:40:30,640
through time and that's of course what

1092
00:40:35,270 --> 00:40:33,200
uh what the exoplanet population will

1093
00:40:37,829 --> 00:40:35,280
bring to the table

1094
00:40:40,069 --> 00:40:37,839
and so we're we're just entering a

1095
00:40:42,790 --> 00:40:40,079
period now when we're going to start to

1096
00:40:46,309 --> 00:40:42,800
get our first data of these uh coming up

1097
00:40:48,630 --> 00:40:46,319
very soon this summer because uh as i'm

1098
00:40:51,349 --> 00:40:48,640
sure you all know the uh the launch of

1099
00:40:55,670 --> 00:40:51,359
jwst was highly successful

1100
00:40:56,390 --> 00:40:55,680
and the the data is uh is doing very

1101
00:40:58,230 --> 00:40:56,400
well

1102
00:41:00,950 --> 00:40:58,240
you may have seen the initial images the

1103
00:41:03,510 --> 00:41:00,960
first light images from james webb and

1104
00:41:07,030 --> 00:41:03,520
um there fortunately there are a number

1105
00:41:09,990 --> 00:41:07,040
of targets which are strong venus zone

1106
00:41:12,230 --> 00:41:10,000
candidates that are in cycle one uh

1107
00:41:14,550 --> 00:41:12,240
guest observer observations and so these

1108
00:41:16,550 --> 00:41:14,560
of course include one of our favorites

1109
00:41:18,309 --> 00:41:16,560
which is trappist-1c

1110
00:41:20,069 --> 00:41:18,319
but there are several others as well

1111
00:41:21,670 --> 00:41:20,079
which are likely terrestrial planets

1112
00:41:22,349 --> 00:41:21,680
gj1132b

1113
00:41:24,069 --> 00:41:22,359

and

1114
00:41:27,270 --> 00:41:24,079
l9859b

1115
00:41:29,589 --> 00:41:27,280
and um so with the challenge will be

1116
00:41:31,510 --> 00:41:29,599
as i said how do we tell the difference

1117
00:41:33,109 --> 00:41:31,520
between a potentially temperate and

1118
00:41:34,550 --> 00:41:33,119
post-runaway greenhouse environments

1119
00:41:37,190 --> 00:41:34,560
when we're only looking at the top of

1120
00:41:39,270 --> 00:41:37,200
the atmosphere clouds of course is going

1121
00:41:40,710 --> 00:41:39,280
to truncate a lot of the information

1122
00:41:41,990 --> 00:41:40,720
that we get from this

1123
00:41:44,069 --> 00:41:42,000
and the

1124
00:41:46,790 --> 00:41:44,079
carbon dioxide absorption features do

1125
00:41:49,270 --> 00:41:46,800
look very very similar for earth and

1126
00:41:51,430 --> 00:41:49,280
venus especially when you are truncating

1127
00:41:55,109 --> 00:41:51,440
with clouds and so this is going to be a

1128
00:41:57,589 --> 00:41:55,119
significant challenge uh and as i said a

1129
00:41:59,430 --> 00:41:57,599
a better knowledge of how that

1130
00:42:02,550 --> 00:41:59,440
extrapolates down to the surface will be

1131
00:42:04,790 --> 00:42:02,560
extremely important and so i'll just

1132
00:42:07,750 --> 00:42:04,800
finish with a couple of comments uh

1133
00:42:09,589 --> 00:42:07,760
general comments about this um as

1134
00:42:11,430 --> 00:42:09,599
as i've been saying understanding more

1135
00:42:13,430 --> 00:42:11,440
about the full atmospheric profile of

1136
00:42:16,230 --> 00:42:13,440
venus is critical and that's why it's

1137
00:42:19,109 --> 00:42:16,240
great news that that we are going back

1138
00:42:21,589 --> 00:42:19,119

to venus and uh and laurie is going to

1139
00:42:23,510 --> 00:42:21,599
be talking about that in more detail in

1140
00:42:25,670 --> 00:42:23,520
a few moments but a couple of takeaway

1141
00:42:27,270 --> 00:42:25,680
points is that as i mentioned the good

1142
00:42:29,670 --> 00:42:27,280
news is that terrestrial planets are

1143
00:42:32,550 --> 00:42:29,680
extremely common and from our

1144
00:42:34,870 --> 00:42:32,560
observational bias we know that venus

1145
00:42:36,630 --> 00:42:34,880
like planets or at least planets that

1146
00:42:39,510 --> 00:42:36,640
are in the venous zone that may be in

1147
00:42:41,670 --> 00:42:39,520
various stages of evolution are also

1148
00:42:43,270 --> 00:42:41,680
extremely common um so some of the

1149
00:42:45,510 --> 00:42:43,280
points that i have to make especially

1150
00:42:47,510 --> 00:42:45,520
especially to my exoplanet colleagues is

1151
00:42:49,190 --> 00:42:47,520
that um when you look at the history of

1152
00:42:50,950 --> 00:42:49,200
exploration of venus we didn't fully

1153
00:42:53,910 --> 00:42:50,960
understand what the surface conditions

1154
00:42:56,630 --> 00:42:53,920
were like until relatively recently the

1155
00:42:58,710 --> 00:42:56,640
clouds for our for the nearest planet

1156
00:43:01,430 --> 00:42:58,720
the nearest earth-sized planet

1157
00:43:02,950 --> 00:43:01,440
really truncated our abilities to

1158
00:43:05,829 --> 00:43:02,960
understand the surface until we went

1159
00:43:08,390 --> 00:43:05,839
there and we will never have any of that

1160
00:43:12,069 --> 00:43:08,400
kind of data for an exoplanet we're not

1161
00:43:13,750 --> 00:43:12,079
sending a probe to proxima centauri b by

1162
00:43:15,589 --> 00:43:13,760
definition of the nearest exoplanet

1163
00:43:18,630 --> 00:43:15,599

we're not doing that certainly within

1164
00:43:22,630 --> 00:43:18,640
our lifetimes or anytime soon that means

1165
00:43:25,670 --> 00:43:22,640
that we must have the best models that

1166
00:43:28,550 --> 00:43:25,680
we can possibly have from venus because

1167
00:43:31,190 --> 00:43:28,560
those models are what the extrapolations

1168
00:43:32,950 --> 00:43:31,200
for exoplanets will inevitably be based

1169
00:43:35,510 --> 00:43:32,960
on and so there's a two-pronged approach

1170
00:43:38,230 --> 00:43:35,520
here there's the intrinsic properties of

1171
00:43:41,589 --> 00:43:38,240
venus there's the statistical properties

1172
00:43:42,470 --> 00:43:41,599
of exoplanets both of those combined uh

1173
00:43:43,829 --> 00:43:42,480
will

1174
00:43:45,589 --> 00:43:43,839
hopefully produce a more complete

1175
00:43:48,150 --> 00:43:45,599
picture of terrestrial planet evolution

1176
00:43:51,349 --> 00:43:48,160
because always remember the axis of time

1177
00:43:52,950 --> 00:43:51,359
the venus that we look at now is almost

1178
00:43:55,109 --> 00:43:52,960
certainly not the same venus if you were

1179
00:43:56,710 --> 00:43:55,119
to observe it at an age of two gig ears

1180
00:43:58,550 --> 00:43:56,720
this is going to be true of exoplanets

1181
00:43:59,990 --> 00:43:58,560
as well sure we'll look at some

1182
00:44:01,349 --> 00:44:00,000
exoplanets that are about four and a

1183
00:44:02,790 --> 00:44:01,359
half giga years old but we'll look at

1184
00:44:05,270 --> 00:44:02,800
some that are eight giga years old and

1185
00:44:07,670 --> 00:44:05,280
some that are three and so that will be

1186
00:44:09,290 --> 00:44:07,680
a really key piece of this puzzle so

1187
00:44:17,349 --> 00:44:09,300
thank you very much

1188
00:44:19,829 --> 00:44:17,359

[Applause]

1189
00:44:21,430 --> 00:44:19,839
thank you so much stephen

1190
00:44:23,190 --> 00:44:21,440
well the four speakers have really set

1191
00:44:26,069 --> 00:44:23,200
up nicely i think why we're all so

1192
00:44:27,829 --> 00:44:26,079
excited about venus and why nasa

1193
00:44:29,990 --> 00:44:27,839
shares that excitement

1194
00:44:31,910 --> 00:44:30,000
and so lori glaze is going to give us an

1195
00:44:33,990 --> 00:44:31,920
overview of what

1196
00:44:35,750 --> 00:44:34,000
as many of you know are exciting plans

1197
00:44:37,670 --> 00:44:35,760
for the near future

1198
00:44:39,990 --> 00:44:37,680
and so lori will speak on the decade of

1199
00:44:42,309 --> 00:44:40,000
venus upcoming nasa missions and

1200
00:44:44,870 --> 00:44:42,319
opportunities

1201
00:44:47,109 --> 00:44:44,880
great thank you tim and hopefully

1202
00:44:48,870 --> 00:44:47,119
everyone can see and hear me

1203
00:44:50,710 --> 00:44:48,880
find and see the slides

1204
00:44:53,190 --> 00:44:50,720
so this has really been a great session

1205
00:44:54,950 --> 00:44:53,200
um and i'm really happy to be back at

1206
00:44:56,790 --> 00:44:54,960
abs icon of course i was there sunday

1207
00:44:58,309 --> 00:44:56,800
and monday and uh wish i could have

1208
00:45:01,270 --> 00:44:58,319
stayed all week but really happy to be

1209
00:45:02,950 --> 00:45:01,280
here today as part of this session

1210
00:45:05,109 --> 00:45:02,960
there is just a tremendous amount of

1211
00:45:07,349 --> 00:45:05,119
excitement surrounding venus and of

1212
00:45:08,790 --> 00:45:07,359
course stimulated in part by those

1213
00:45:10,550 --> 00:45:08,800

observations that have been talked about

1214
00:45:12,550 --> 00:45:10,560
today that have potentially been

1215
00:45:14,790 --> 00:45:12,560
interpreted as phosphine

1216
00:45:16,230 --> 00:45:14,800
in the venous atmosphere but let me just

1217
00:45:17,829 --> 00:45:16,240
kind of back up a little bit kind of

1218
00:45:19,670 --> 00:45:17,839
going back to some of what candy said at

1219
00:45:21,910 --> 00:45:19,680
the beginning talk a little bit about

1220
00:45:24,230 --> 00:45:21,920
the venus history and why we care um

1221
00:45:25,910 --> 00:45:24,240
even in more broad sense

1222
00:45:28,309 --> 00:45:25,920
of course venus has been mentioned

1223
00:45:29,750 --> 00:45:28,319
several times is is very similar to

1224
00:45:31,030 --> 00:45:29,760
earth in fact formed in the same part of

1225
00:45:32,790 --> 00:45:31,040
the solar system out of the same

1226
00:45:34,630 --> 00:45:32,800
materials and should have had very

1227
00:45:37,030 --> 00:45:34,640
similar origins to earth and this has

1228
00:45:38,230 --> 00:45:37,040
also been alluded to the fact that you

1229
00:45:40,790 --> 00:45:38,240
can see on the left the artist's

1230
00:45:42,309 --> 00:45:40,800
rendition again of what we believe venus

1231
00:45:44,150 --> 00:45:42,319
looked like

1232
00:45:46,630 --> 00:45:44,160
several billion years ago when it was in

1233
00:45:48,630 --> 00:45:46,640
fact covered in water we believe it to

1234
00:45:50,870 --> 00:45:48,640
be covered in water because of measure

1235
00:45:52,790 --> 00:45:50,880
measurements taken by that pioneer

1236
00:45:55,109 --> 00:45:52,800
venous probe as it descended through the

1237
00:45:57,349 --> 00:45:55,119
atmosphere in 1978

1238
00:45:59,990 --> 00:45:57,359

and measured the deuterium to hydrogen

1239
00:46:01,510 --> 00:46:00,000
ratio which indicated that

1240
00:46:03,190 --> 00:46:01,520
the hydrogen of course which

1241
00:46:05,589 --> 00:46:03,200
preferentially escapes was depleted

1242
00:46:07,030 --> 00:46:05,599
compared to the deuterium to an effect

1243
00:46:09,430 --> 00:46:07,040
an extent that

1244
00:46:11,270 --> 00:46:09,440
seems to indicate large volumes of water

1245
00:46:13,349 --> 00:46:11,280
in venus's past

1246
00:46:16,630 --> 00:46:13,359
we know that over time it has evolved

1247
00:46:18,790 --> 00:46:16,640
into what we have today this um hot and

1248
00:46:20,870 --> 00:46:18,800
desiccated environment on venus that's

1249
00:46:23,030 --> 00:46:20,880
that's present today but we don't know

1250
00:46:25,270 --> 00:46:23,040
when or how that happened

1251
00:46:26,790 --> 00:46:25,280
and i think as steve is really alluding

1252
00:46:29,030 --> 00:46:26,800
to there this is critical to

1253
00:46:31,030 --> 00:46:29,040
understanding you know how do these

1254
00:46:33,349 --> 00:46:31,040
planets evolve and why what makes a

1255
00:46:34,710 --> 00:46:33,359
planet go in a path uh

1256
00:46:37,270 --> 00:46:34,720
similar to earth

1257
00:46:39,990 --> 00:46:37,280
or you know in a path similar to venus

1258
00:46:41,829 --> 00:46:40,000
and as we're thinking about all of the

1259
00:46:43,829 --> 00:46:41,839
various exoplanets that steve was just

1260
00:46:45,270 --> 00:46:43,839
talking about stephen's talking about

1261
00:46:46,950 --> 00:46:45,280
how do we

1262
00:46:48,550 --> 00:46:46,960
identify

1263
00:46:50,470 --> 00:46:48,560

potential targets that are potentially

1264
00:46:52,150 --> 00:46:50,480
habitable and and we need to be able to

1265
00:46:54,790 --> 00:46:52,160
understand

1266
00:46:56,870 --> 00:46:54,800
what what makes a venus and what makes

1267
00:46:59,109 --> 00:46:56,880
an earth and how can we uh distinguish

1268
00:47:01,109 --> 00:46:59,119
those at their various stages through

1269
00:47:02,230 --> 00:47:01,119
their evolution across

1270
00:47:04,630 --> 00:47:02,240
time

1271
00:47:07,030 --> 00:47:04,640
so let's just i want to spend a couple

1272
00:47:08,950 --> 00:47:07,040
of seconds here talking about what we do

1273
00:47:12,069 --> 00:47:08,960
know the missions that we have had at

1274
00:47:15,030 --> 00:47:12,079
venus before i talk about what's next

1275
00:47:17,430 --> 00:47:15,040
um i love this chart it shows that

1276
00:47:19,430 --> 00:47:17,440
across the top are all of the missions

1277
00:47:21,510 --> 00:47:19,440
that have targeted venus and if you look

1278
00:47:23,349 --> 00:47:21,520
to the far left you can see

1279
00:47:25,670 --> 00:47:23,359
the beginnings of the soviet union with

1280
00:47:27,349 --> 00:47:25,680
their many veneer emissions that landed

1281
00:47:29,589 --> 00:47:27,359
on the surface of venus and the pioneer

1282
00:47:31,910 --> 00:47:29,599
venus mission uh from the u.s which

1283
00:47:33,270 --> 00:47:31,920
included four atmospheric probes and an

1284
00:47:35,510 --> 00:47:33,280
orbiter

1285
00:47:37,349 --> 00:47:35,520
those missions uh while uh you know

1286
00:47:39,270 --> 00:47:37,359
successful and were able to collect some

1287
00:47:42,390 --> 00:47:39,280
data we're in the really kind of the

1288
00:47:44,069 --> 00:47:42,400

nascent days of uh planetary exploration

1289
00:47:46,549 --> 00:47:44,079
and so while we have some data they

1290
00:47:47,829 --> 00:47:46,559
leave a lot to be desired um as we try

1291
00:47:49,670 --> 00:47:47,839
to interpret there's a lot of

1292
00:47:51,270 --> 00:47:49,680
uncertainties in the data

1293
00:47:53,670 --> 00:47:51,280
there were challenges for example with

1294
00:47:55,990 --> 00:47:53,680
the pioneer venus probe as it descended

1295
00:47:58,390 --> 00:47:56,000
through the atmosphere the the inlet

1296
00:48:00,309 --> 00:47:58,400
sucked in a a sulfuric acid droplet

1297
00:48:03,109 --> 00:48:00,319
which then clogged the inlet for the

1298
00:48:06,470 --> 00:48:03,119
rest of the descent and so we have a

1299
00:48:08,309 --> 00:48:06,480
really poor or a lot of missing data in

1300
00:48:10,069 --> 00:48:08,319
the lower parts of the venous atmosphere

1301
00:48:13,030 --> 00:48:10,079
regarding the chemistry and other

1302
00:48:14,309 --> 00:48:13,040
parameters within the atmosphere

1303
00:48:16,710 --> 00:48:14,319
following those missions of course the

1304
00:48:20,390 --> 00:48:16,720
u.s spent sent magellan in the early

1305
00:48:23,109 --> 00:48:20,400
1990s which mapped out uh the surface of

1306
00:48:25,670 --> 00:48:23,119
venus using a radar system uh to give us

1307
00:48:28,230 --> 00:48:25,680
the images and and to a rough degree

1308
00:48:29,829 --> 00:48:28,240
some topography but again the resolution

1309
00:48:31,510 --> 00:48:29,839
of those images and the resolution of

1310
00:48:33,109 --> 00:48:31,520
that topography is very low for

1311
00:48:36,390 --> 00:48:33,119
understanding the processes that are

1312
00:48:39,349 --> 00:48:36,400
going on at venus more recently european

1313
00:48:42,309 --> 00:48:39,359

space agency and japanese space agencies

1314
00:48:43,750 --> 00:48:42,319
sent uh missions to venus akutskiy is

1315
00:48:47,030 --> 00:48:43,760
still operating

1316
00:48:50,150 --> 00:48:47,040
that studied the atmosphere from orbit

1317
00:48:51,589 --> 00:48:50,160
and the weather at venus

1318
00:48:53,430 --> 00:48:51,599
there have been a variety of other

1319
00:48:55,349 --> 00:48:53,440
missions that have in the bottom there

1320
00:48:57,270 --> 00:48:55,359
with the blue circles around them that

1321
00:48:59,030 --> 00:48:57,280
have flown by they have other target

1322
00:49:01,510 --> 00:48:59,040
destinations but have flown by venus and

1323
00:49:03,190 --> 00:49:01,520
giving us various ad-hoc observations

1324
00:49:05,109 --> 00:49:03,200
but the key takeaway here is that the

1325
00:49:07,109 --> 00:49:05,119
united states hasn't been

1326
00:49:10,950 --> 00:49:07,119
at venus hasn't sent a mission to venus

1327
00:49:13,349 --> 00:49:10,960
since the early 1990s and we haven't had

1328
00:49:15,910 --> 00:49:13,359
any in-situ missions at venus that can

1329
00:49:18,309 --> 00:49:15,920
provide the data that have been argued

1330
00:49:20,309 --> 00:49:18,319
for today here in the various session

1331
00:49:21,190 --> 00:49:20,319
session talks we haven't had an in-situ

1332
00:49:24,790 --> 00:49:21,200
mission

1333
00:49:26,710 --> 00:49:24,800
since uh the early 1980s and so there

1334
00:49:28,390 --> 00:49:26,720
really is a lot of

1335
00:49:30,470 --> 00:49:28,400
information needed

1336
00:49:32,630 --> 00:49:30,480
and we have from what we from the

1337
00:49:34,309 --> 00:49:32,640
missions that have already flown

1338
00:49:36,710 --> 00:49:34,319

the the good thing is that we have

1339
00:49:37,589 --> 00:49:36,720
enough information to set forth a bunch

1340
00:49:39,349 --> 00:49:37,599
of

1341
00:49:42,150 --> 00:49:39,359
really good hypotheses that can be

1342
00:49:44,790 --> 00:49:42,160
tested uh well with a series of missions

1343
00:49:45,910 --> 00:49:44,800
and so we're really excited last summer

1344
00:49:48,309 --> 00:49:45,920
that

1345
00:49:50,069 --> 00:49:48,319
several missions were selected to fly to

1346
00:49:51,910 --> 00:49:50,079
venus and i'll talk a little bit about

1347
00:49:53,829 --> 00:49:51,920
each of these

1348
00:49:55,910 --> 00:49:53,839
first off there was the veritas mission

1349
00:49:57,430 --> 00:49:55,920
which was selected this is a mission

1350
00:49:59,990 --> 00:49:57,440
that will fly

1351
00:50:02,309 --> 00:50:00,000
a radar system an x-band radar system

1352
00:50:04,470 --> 00:50:02,319
with dual antennas which allows it to

1353
00:50:06,230 --> 00:50:04,480
map out in detail the topography of

1354
00:50:08,390 --> 00:50:06,240
venus and again this is critically

1355
00:50:10,150 --> 00:50:08,400
important for understanding the surface

1356
00:50:12,790 --> 00:50:10,160
and interior which sets the

1357
00:50:15,190 --> 00:50:12,800
environmental context for

1358
00:50:16,309 --> 00:50:15,200
what's happening on venus today and in

1359
00:50:18,150 --> 00:50:16,319
the past

1360
00:50:20,390 --> 00:50:18,160
this will be the first time we've ever

1361
00:50:23,030 --> 00:50:20,400
been able to map out the topography of

1362
00:50:25,109 --> 00:50:23,040
the surface at this level of detail

1363
00:50:26,470 --> 00:50:25,119

it'll be essentially equivalent to some

1364
00:50:28,630 --> 00:50:26,480
of the things we can do

1365
00:50:30,870 --> 00:50:28,640
now on mars

1366
00:50:32,790 --> 00:50:30,880
the da vinci mission which has been

1367
00:50:34,630 --> 00:50:32,800
mentioned a couple times

1368
00:50:37,270 --> 00:50:34,640
is a mission to send an atmospheric

1369
00:50:39,589 --> 00:50:37,280
probe into the venus atmosphere to

1370
00:50:42,230 --> 00:50:39,599
sample all the way to the surface it'll

1371
00:50:44,470 --> 00:50:42,240
begin sampling in the cloud layer um it

1372
00:50:46,710 --> 00:50:44,480
has mass spectrometer mass spectrometer

1373
00:50:47,990 --> 00:50:46,720
that can measure noble gases i will also

1374
00:50:50,470 --> 00:50:48,000
measure

1375
00:50:52,230 --> 00:50:50,480
the water content and and trace gases

1376
00:50:54,630 --> 00:50:52,240
other trace gases all the way to the

1377
00:50:55,750 --> 00:50:54,640
surface giving us the first in-depth

1378
00:50:58,069 --> 00:50:55,760
look at

1379
00:50:59,910 --> 00:50:58,079
the chemistry profile in that deepest

1380
00:51:01,910 --> 00:50:59,920
part of the venus atmosphere where no

1381
00:51:03,670 --> 00:51:01,920
data have ever been collected in situ

1382
00:51:05,670 --> 00:51:03,680
before so this mission is going to

1383
00:51:07,829 --> 00:51:05,680
collect data that have never uh we've

1384
00:51:09,349 --> 00:51:07,839
never been able to collect that require

1385
00:51:11,589 --> 00:51:09,359
being in situ in that part of the

1386
00:51:12,870 --> 00:51:11,599
atmosphere and also of course collect

1387
00:51:16,069 --> 00:51:12,880
other environmental parameters

1388
00:51:17,670 --> 00:51:16,079

temperature pressure winds etc

1389
00:51:19,349 --> 00:51:17,680
both of those missions veritas and da

1390
00:51:22,470 --> 00:51:19,359
vinci were selected

1391
00:51:24,950 --> 00:51:22,480
by nasa to fly and

1392
00:51:27,430 --> 00:51:24,960
coincidentally at the same time european

1393
00:51:28,790 --> 00:51:27,440
space agency also selected a venus

1394
00:51:30,870 --> 00:51:28,800
mission to fly

1395
00:51:34,309 --> 00:51:30,880
the envision mission

1396
00:51:36,230 --> 00:51:34,319
envision is we'll also fly a a radar

1397
00:51:38,630 --> 00:51:36,240
system this time an s-band radar which

1398
00:51:41,030 --> 00:51:38,640
will give very high resolution radar

1399
00:51:42,390 --> 00:51:41,040
images of the surface again helping to

1400
00:51:44,630 --> 00:51:42,400
characterize

1401
00:51:46,390 --> 00:51:44,640
the processes geologic processes on the

1402
00:51:49,270 --> 00:51:46,400
surface including whether or not there

1403
00:51:52,950 --> 00:51:49,280
may be active volcanism present on venus

1404
00:51:54,630 --> 00:51:52,960
today it also carries a uh infrared

1405
00:51:56,309 --> 00:51:54,640
spectrometer

1406
00:51:57,750 --> 00:51:56,319
that will be able to

1407
00:51:59,349 --> 00:51:57,760
map out

1408
00:52:01,670 --> 00:51:59,359
some of the composition of the surface

1409
00:52:03,750 --> 00:52:01,680
but also doing detailed compositional

1410
00:52:05,349 --> 00:52:03,760
profiles with the spectrometer of the

1411
00:52:07,349 --> 00:52:05,359
atmosphere again

1412
00:52:09,990 --> 00:52:07,359
and very complementary to both the

1413
00:52:11,190 --> 00:52:10,000

veritas and da vinci missions the radar

1414
00:52:13,670 --> 00:52:11,200
for the envision mission is being

1415
00:52:15,990 --> 00:52:13,680
contributed by nasa so we see this as a

1416
00:52:18,309 --> 00:52:16,000
really complementary program by both

1417
00:52:20,390 --> 00:52:18,319
nasa and esa for this decade of venus

1418
00:52:22,790 --> 00:52:20,400
exploration there's a lot of other

1419
00:52:26,069 --> 00:52:22,800
interests in venus exploration as well

1420
00:52:27,510 --> 00:52:26,079
including private uh private uh in

1421
00:52:29,589 --> 00:52:27,520
private companies that are interested in

1422
00:52:31,349 --> 00:52:29,599
flying to venus and flying some missions

1423
00:52:33,109 --> 00:52:31,359
or other international agencies

1424
00:52:34,069 --> 00:52:33,119
including india and russia with

1425
00:52:36,790 --> 00:52:34,079
interests

1426
00:52:38,630 --> 00:52:36,800
so this really is a compelling time i

1427
00:52:40,230 --> 00:52:38,640
expect that

1428
00:52:43,109 --> 00:52:40,240
by the mid

1429
00:52:45,270 --> 00:52:43,119
2030s we are going to have an incredible

1430
00:52:47,510 --> 00:52:45,280
wealth of data to help us answer some of

1431
00:52:49,750 --> 00:52:47,520
these important questions that you've

1432
00:52:52,150 --> 00:52:49,760
heard about here today

1433
00:52:54,230 --> 00:52:52,160
i just wanted to real quick before i

1434
00:52:56,790 --> 00:52:54,240
close out just give one more shout out

1435
00:52:58,710 --> 00:52:56,800
to our planetary science astrobiology

1436
00:53:00,870 --> 00:52:58,720
decadal survey

1437
00:53:03,190 --> 00:53:00,880
that we are looking forward to uh

1438
00:53:04,710 --> 00:53:03,200

reviewing that and getting more uh more

1439
00:53:07,829 --> 00:53:04,720
feedback to the community on what's in

1440
00:53:09,990 --> 00:53:07,839
that that survey but there is a lot of

1441
00:53:11,670 --> 00:53:10,000
uh great context in there for venus

1442
00:53:14,549 --> 00:53:11,680
exploration as well including an

1443
00:53:16,150 --> 00:53:14,559
opportunity for a new frontiers uh

1444
00:53:18,549 --> 00:53:16,160
target for one of our new frontiers

1445
00:53:21,589 --> 00:53:18,559
missions uh in the in the calls uh at

1446
00:53:23,910 --> 00:53:21,599
the later part of this decade so uh stay

1447
00:53:25,270 --> 00:53:23,920
and stay tuned for that and with that i

1448
00:53:34,069 --> 00:53:25,280
think i'm gonna stop so that we have

1449
00:53:38,150 --> 00:53:35,829
thanks so much lori for that excellent

1450
00:53:39,270 --> 00:53:38,160
overview given the data that we're about

1451
00:53:40,950 --> 00:53:39,280
to have we're going to run out of

1452
00:53:42,470 --> 00:53:40,960
excuses for not answering those most

1453
00:53:45,510 --> 00:53:42,480
important questions and that's a great

1454
00:53:47,910 --> 00:53:47,109
before you do that um let's bring our

1455
00:53:50,069 --> 00:53:47,920
three

1456
00:53:52,150 --> 00:53:50,079
speakers present back up on the stage

1457
00:53:53,430 --> 00:53:52,160
and so we have maybe eight minutes or so

1458
00:53:55,589 --> 00:53:53,440
for questions but what i really

1459
00:53:57,670 --> 00:53:55,599
encourage you to do is follow them out

1460
00:53:59,750 --> 00:53:57,680
into the hallway and you'll have

1461
00:54:01,030 --> 00:53:59,760
infinite time then and so we already

1462
00:54:05,270 --> 00:54:01,040
have a hand up and we have a first

1463
00:54:08,470 --> 00:54:06,950

thank you all for the lovely talks i

1464
00:54:10,710 --> 00:54:08,480
just wanted to

1465
00:54:13,430 --> 00:54:10,720
ask if folks have looked uh for the

1466
00:54:14,230 --> 00:54:13,440
phosphene if there is phosphene

1467
00:54:15,990 --> 00:54:14,240
um

1468
00:54:18,309 --> 00:54:16,000
in the cloud decks of venus

1469
00:54:20,870 --> 00:54:18,319
um have have you all delved really

1470
00:54:25,190 --> 00:54:20,880
deeply into the microbial literature of

1471
00:54:28,069 --> 00:54:25,200
which there is about 30 years or more

1472
00:54:30,150 --> 00:54:28,079
although more than that 40 50 years of

1473
00:54:32,150 --> 00:54:30,160
looking at this as far as i know it's

1474
00:54:34,309 --> 00:54:32,160
only been found in

1475
00:54:36,950 --> 00:54:34,319
anoxic sediments and there's no

1476
00:54:38,549 --> 00:54:36,960
microbial pathway that's been sorted out

1477
00:54:40,950 --> 00:54:38,559
the burden of proof really in

1478
00:54:42,630 --> 00:54:40,960
microbiology is to uh to say that

1479
00:54:46,230 --> 00:54:42,640
something is biological is really to

1480
00:54:48,630 --> 00:54:46,240
establish an enzymatic pathway so if an

1481
00:54:51,270 --> 00:54:48,640
enzymatic pathway has not been found is

1482
00:54:53,510 --> 00:54:51,280
this community actively looking for one

1483
00:54:54,710 --> 00:54:53,520
because that would be a burden in order

1484
00:54:57,510 --> 00:54:54,720
to

1485
00:55:00,230 --> 00:54:57,520
establish anything as biogenic so far

1486
00:55:02,069 --> 00:55:00,240
the literature most microbiologists as

1487
00:55:05,030 --> 00:55:02,079
far as i know think that it is uh

1488
00:55:07,030 --> 00:55:05,040

abiotic that it's chemical and there are

1489
00:55:09,910 --> 00:55:07,040
mechanisms established for that and

1490
00:55:12,950 --> 00:55:09,920
published thank you

1491
00:55:14,630 --> 00:55:12,960
yeah uh is this okay okay i think that

1492
00:55:16,549 --> 00:55:14,640
might be a question for me

1493
00:55:18,230 --> 00:55:16,559
um so the work on this has been led by i

1494
00:55:20,789 --> 00:55:18,240
think janice butkowski william baines

1495
00:55:22,870 --> 00:55:20,799
and clara suza silva and i think in

1496
00:55:25,270 --> 00:55:22,880
their work they lay out a case for

1497
00:55:26,870 --> 00:55:25,280
why phosphine is biogenic

1498
00:55:28,630 --> 00:55:26,880
to my understanding the phosphate

1499
00:55:30,390 --> 00:55:28,640
reduction on earth that's available is

1500
00:55:33,349 --> 00:55:30,400
not demonstrated data is not an

1501
00:55:35,270 --> 00:55:33,359
enzymatic pathway but there is some like

1502
00:55:37,349 --> 00:55:35,280
it is does seem to be associated with

1503
00:55:38,789 --> 00:55:37,359
biological production one other kind of

1504
00:55:40,630 --> 00:55:38,799
key point to note is that most of the

1505
00:55:42,710 --> 00:55:40,640
molecules produced by life we don't seem

1506
00:55:44,390 --> 00:55:42,720
to have a clear enzymatic path before

1507
00:55:46,150 --> 00:55:44,400
and so for that i might say that it

1508
00:55:47,510 --> 00:55:46,160
there's as you point out a lot of room

1509
00:55:49,829 --> 00:55:47,520
for really great experimental work to

1510
00:55:51,589 --> 00:55:49,839
kind of trace out what's going on and so

1511
00:55:55,510 --> 00:55:51,599
that's something i think that this team

1512
00:55:59,750 --> 00:55:57,990
thank you um let's go over here i think

1513
00:56:02,069 --> 00:55:59,760

my eyes are failing me but that's steve

1514
00:56:03,829 --> 00:56:02,079
better yeah yeah card carrying member of

1515
00:56:05,910 --> 00:56:03,839
the organic division of the american

1516
00:56:07,990 --> 00:56:05,920
chemical society i'm obligated to point

1517
00:56:10,870 --> 00:56:08,000
out to astronomers and geologists the

1518
00:56:13,670 --> 00:56:10,880
importance of organic chemistry when

1519
00:56:16,950 --> 00:56:13,680
studying a problem especially for venus

1520
00:56:19,270 --> 00:56:16,960
where our intuitions are so bad based on

1521
00:56:21,910 --> 00:56:19,280
organic chemistry that we observe in the

1522
00:56:23,510 --> 00:56:21,920
biosphere on earth so so this but we'll

1523
00:56:25,430 --> 00:56:23,520
talk about synthetic biology that's we

1524
00:56:27,910 --> 00:56:25,440
need people in the laboratory who are

1525
00:56:29,910 --> 00:56:27,920
actually trying to construct

1526
00:56:31,829 --> 00:56:29,920
organic chemistry that might for example

1527
00:56:33,910 --> 00:56:31,839
produce genetic systems we have jan

1528
00:56:35,910 --> 00:56:33,920
schwatzek and gage owens who are here

1529
00:56:39,030 --> 00:56:35,920
who are actually doing that one of the

1530
00:56:40,950 --> 00:56:39,040
amusing things is first how little our

1531
00:56:43,349 --> 00:56:40,960
general impression of how chemistry

1532
00:56:45,510 --> 00:56:43,359
works in water can be transferred to

1533
00:56:47,270 --> 00:56:45,520
concentrated sulfuric acid

1534
00:56:49,109 --> 00:56:47,280
but then the surprise is that yeah we

1535
00:56:51,270 --> 00:56:49,119
can actually generate if we can get

1536
00:56:52,950 --> 00:56:51,280
certain levels of one carbon species

1537
00:56:55,829 --> 00:56:52,960
like formaldehyde

1538
00:56:57,829 --> 00:56:55,839

polymers for example polyglycolic acid

1539
00:56:59,270 --> 00:56:57,839
that are remarkably stable in these

1540
00:57:00,870 --> 00:56:59,280
environments that could in fact be a

1541
00:57:02,630 --> 00:57:00,880
genetic molecule

1542
00:57:04,950 --> 00:57:02,640
but we wouldn't know that unless we had

1543
00:57:07,109 --> 00:57:04,960
no nasa does not do organic chemistry

1544
00:57:09,270 --> 00:57:07,119
right nasa flies missions does excellent

1545
00:57:11,750 --> 00:57:09,280
astronomy excellent geology but

1546
00:57:13,190 --> 00:57:11,760
um until we actually spend some time in

1547
00:57:15,510 --> 00:57:13,200
the laboratory with concentrated

1548
00:57:17,030 --> 00:57:15,520
sulfuric acid we really don't know what

1549
00:57:19,589 --> 00:57:17,040
we should be looking for in the way of

1550
00:57:20,789 --> 00:57:19,599
organic molecules because our intuition

1551
00:57:24,230 --> 00:57:20,799
has been

1552
00:57:25,510 --> 00:57:24,240
so poor in the past so that's my comment

1553
00:57:28,230 --> 00:57:25,520
thanks steve

1554
00:57:30,309 --> 00:57:28,240
i think we have time for one more so

1555
00:57:32,789 --> 00:57:30,319
go for it great hi this is stephanie

1556
00:57:34,870 --> 00:57:32,799
getty from nasa goddard and da vinci um

1557
00:57:36,390 --> 00:57:34,880
and it's a i just wanted to congratulate

1558
00:57:39,030 --> 00:57:36,400
everybody on an amazing session this

1559
00:57:41,829 --> 00:57:39,040
morning i was enthralled um on behalf of

1560
00:57:43,589 --> 00:57:41,839
davinci also i want to express uh

1561
00:57:46,150 --> 00:57:43,599
encouragement it's a little bit of an

1562
00:57:48,549 --> 00:57:46,160
advertisement we we have a trade study

1563
00:57:50,789 --> 00:57:48,559

that's going on right now to consider uh

1564
00:57:53,030 --> 00:57:50,799
whether we can um uh

1565
00:57:56,150 --> 00:57:53,040
define a slightly

1566
00:57:59,030 --> 00:57:56,160
expanded scope of one of our instruments

1567
00:58:02,710 --> 00:57:59,040
and it's not as expensive it's a trade

1568
00:58:04,870 --> 00:58:02,720
study during our our phase b here uh to

1569
00:58:06,710 --> 00:58:04,880
look at um you know additional

1570
00:58:09,750 --> 00:58:06,720
measurement targets and i'd encourage

1571
00:58:11,190 --> 00:58:09,760
you all to uh you know

1572
00:58:12,069 --> 00:58:11,200
get in touch with us on the team we're

1573
00:58:15,589 --> 00:58:12,079
going to have

1574
00:58:17,829 --> 00:58:15,599
a a roundtable discussion and engaging

1575
00:58:19,829 --> 00:58:17,839
the community and we'd love to hear

1576
00:58:22,309 --> 00:58:19,839
hypotheses that could be formulated

1577
00:58:23,670 --> 00:58:22,319
based on measurement targets that we'll

1578
00:58:25,510 --> 00:58:23,680
make

1579
00:58:26,789 --> 00:58:25,520
during our descent through that

1580
00:58:28,309 --> 00:58:26,799
excuse me through the atmosphere of

1581
00:58:30,950 --> 00:58:28,319
venus and we're really looking forward

1582
00:58:33,910 --> 00:58:30,960
to contributing new awareness and new

1583
00:58:35,990 --> 00:58:33,920
data to this really energized community

1584
00:58:38,309 --> 00:58:36,000
so um thanks for all you do and hope to

1585
00:58:40,630 --> 00:58:38,319
hear from you

1586
00:58:42,630 --> 00:58:40,640
thank you very much um unfortunately we

1587
00:58:44,549 --> 00:58:42,640
have a hard stop but again i encourage

1588
00:58:47,109 --> 00:58:44,559

you to follow up

1589
00:58:49,510 --> 00:58:47,119
after this in the hallway and so let me

1590
00:58:51,990 --> 00:58:49,520
just take this opportunity to thank all

1591
00:58:55,030 --> 00:58:52,000
the speakers for an excellent session

1592
00:58:57,349 --> 00:58:55,040
and to thank them for just ramping even

1593
00:59:19,190 --> 00:58:57,359
up further my interest in venus so let's

1594
00:59:25,829 --> 00:59:21,109
we're not over yet can everybody just

1595
00:59:30,150 --> 00:59:27,910
oh i have i have no slides

1596
00:59:32,470 --> 00:59:30,160
so um now that we're just about at the

1597
00:59:35,510 --> 00:59:32,480
close of appsicon i'd like to just start

1598
00:59:38,870 --> 00:59:35,520
out a round of thank yous so the first

1599
00:59:41,270 --> 00:59:38,880
one i want to um to make is for somebody

1600
00:59:43,430 --> 00:59:41,280
who is not here with us but is very much

1601
00:59:49,030 --> 00:59:43,440
at the heart of abs icon and that's mary

1602
00:59:56,470 --> 00:59:53,190
and um next a very strong thank you for

1603
00:59:59,430 --> 00:59:56,480
our local organizing committee so jen

1604
01:00:01,270 --> 00:59:59,440
glass and martha grover and frank

1605
01:00:04,309 --> 01:00:01,280
rosensweight from georgia tech who

1606
01:00:13,270 --> 01:00:04,319
created a fabulous abscess concourse and

1607
01:00:17,829 --> 01:00:15,589
and thank you oops

1608
01:00:25,030 --> 01:00:17,839
oh i forgot the microphone that was my

1609
01:00:29,829 --> 01:00:27,670
and thank you melissa who is also our

1610
01:00:30,950 --> 01:00:29,839
key organizer thank you

1611
01:00:32,350 --> 01:00:30,960
and

1612
01:00:34,950 --> 01:00:32,360
great let's cheer

1613
01:00:37,910 --> 01:00:34,960

[Applause]

1614
01:00:39,510 --> 01:00:37,920
and i'd like to thank our amazing av

1615
01:00:40,870 --> 01:00:39,520
support staff

1616
01:00:42,390 --> 01:00:40,880
marco

1617
01:00:45,190 --> 01:00:42,400
joseph

1618
01:00:54,829 --> 01:00:45,200
john anthony and james let's give them a

1619
01:00:59,829 --> 01:00:57,750
okay have i learned anything in this

1620
01:01:02,150 --> 01:00:59,839
pandemic is that there's no such thing

1621
01:01:04,390 --> 01:01:02,160
as a non-essential worker

1622
01:01:06,630 --> 01:01:04,400
but in my life over the last few months

1623
01:01:11,030 --> 01:01:06,640
some of the most essential people

1624
01:01:15,829 --> 01:01:13,270
who have really helped the

1625
01:01:17,109 --> 01:01:15,839
local and the wider science organizing

1626
01:01:20,309 --> 01:01:17,119
committee

1627
01:01:23,349 --> 01:01:20,319
follow this moving target as we

1628
01:01:26,150 --> 01:01:23,359
sought to bring us together

1629
01:01:28,950 --> 01:01:26,160
and do so in a way that's that's safe

1630
01:01:32,069 --> 01:01:28,960
for everyone so a special shout out

1631
01:01:33,030 --> 01:01:32,079
to uh the people on the uh the left hand

1632
01:01:35,510 --> 01:01:33,040
side

1633
01:01:36,950 --> 01:01:35,520
uh heather naley who is the chief

1634
01:01:39,750 --> 01:01:36,960
coordinator

1635
01:01:42,870 --> 01:01:39,760
as well as folks like victoria and amy

1636
01:01:44,549 --> 01:01:42,880
becky nicole justine and lauren

1637
01:01:47,030 --> 01:01:44,559
thank you so much

1638
01:01:50,840 --> 01:01:47,040

and without your help this meeting would

1639
01:02:00,789 --> 01:01:50,850
have been impossible so thanks to agu

1640
01:02:13,270 --> 01:02:03,270
one more round of applause for

1641
01:02:17,109 --> 01:02:14,870
and finally we'd like to thank the

1642
01:02:19,670 --> 01:02:17,119
partners and sponsors

1643
01:02:21,510 --> 01:02:19,680
nasa scope applied physics laboratory at

1644
01:02:24,630 --> 01:02:21,520
johns hopkins blue marble space

1645
01:02:27,190 --> 01:02:24,640
institute life american society for

1646
01:02:28,710 --> 01:02:27,200
microbiology american astronomical

1647
01:02:30,549 --> 01:02:28,720
society thank you all so much for

1648
01:02:35,349 --> 01:02:30,559
helping us to all come together here

1649
01:02:39,829 --> 01:02:37,430
we'd like to thank all the hilton

1650
01:02:41,750 --> 01:02:39,839
personnel so that we could really all

1651
01:02:42,950 --> 01:02:41,760
gather here together

1652
01:02:46,870 --> 01:02:42,960
safely

1653
01:02:49,589 --> 01:02:46,880
in a clean environment housekeepers

1654
01:02:59,029 --> 01:02:49,599
servers food staff everyone thank you so

1655
01:03:03,829 --> 01:03:01,190
uh and and finally

1656
01:03:06,230 --> 01:03:03,839
thank you to all the conveners all of

1657
01:03:08,630 --> 01:03:06,240
the session chairs and all of the

1658
01:03:10,870 --> 01:03:08,640
participants so thank you all coming

1659
01:03:13,510 --> 01:03:10,880
here or joining online

1660
01:03:19,670 --> 01:03:13,520
so glad to have all of you here together

1661
01:03:19,680 --> 01:03:23,349
have a great day