4

Could Micrometeorites be Responsible for High Altitude Water Ice Clouds on Mars?

1
00:00:10,610 --> 00:00:08,629
so I realize I'm the only thing standing

2
00:00:13,310 --> 00:00:10,620
between you and your free time and your

3
00:00:15,499 --> 00:00:13,320
dinner so I will endeavor to be as

4
00:00:17,930 --> 00:00:15,509
interesting as possible and hopefully

5
00:00:20,660 --> 00:00:17,940
give you a bit of information to take

6
00:00:22,849 --> 00:00:20,670
with you my name is Victoria hartwick

7
00:00:25,040 --> 00:00:22,859
I'm also one of the contingent of people

8
00:00:29,839 --> 00:00:25,050
who work just down the road at

9
00:00:32,749 --> 00:00:29,849
cu-boulder but I put up a very

10
00:00:34,240 --> 00:00:32,759
complicate or complicated title but I'm

11
00:00:36,770 --> 00:00:34,250
since this is an interdisciplinary

12
00:00:38,840 --> 00:00:36,780
conference I'm going to try to take a

13
00:00:41,360 --> 00:00:38,850

bit of a step back and show how this

14
00:00:43,880 --> 00:00:41,370
work can be relevant to other planetary

15
00:00:46,400 --> 00:00:43,890
systems but also within an astra

16
00:00:50,420 --> 00:00:46,410
biological context so with that in mind

17
00:00:51,979 --> 00:00:50,430
I've tried to create two points as a

18
00:00:55,459 --> 00:00:51,989
sort of framework for the rest of this

19
00:00:58,549 --> 00:00:55,469
talk the first of which is no man and no

20
00:01:01,130 --> 00:00:58,559
planet is an island and we may need to

21
00:01:04,369 --> 00:01:01,140
really consider planetary climate in a

22
00:01:06,440 --> 00:01:04,379
within the context of a broader system

23
00:01:07,910 --> 00:01:06,450
so when we typically think of planetary

24
00:01:10,550 --> 00:01:07,920
climate we think of factors that are

25
00:01:13,250 --> 00:01:10,560
endogenous to that planet we think about

26
00:01:18,289 --> 00:01:13,260
the composition of the atmosphere any

27
00:01:23,330 --> 00:01:18,299
type of any type of volcanic activity

28
00:01:25,100 --> 00:01:23,340
the fraction of water to land but it may

29
00:01:27,469 --> 00:01:25,110
be equally important to consider factors

30
00:01:30,350 --> 00:01:27,479
that are external to the system so

31
00:01:34,069 --> 00:01:30,360
things like the evolution of the solar

32
00:01:36,890 --> 00:01:34,079
output the impact on the short and long

33
00:01:39,590 --> 00:01:36,900
term of asteroidal impacts and in the

34
00:01:42,700 --> 00:01:39,600
case of this research what is the effect

35
00:01:46,120 --> 00:01:42,710
of a continuous flux of small particles

36
00:01:49,160 --> 00:01:46,130
at the top of the Mars atmosphere and

37
00:01:51,530 --> 00:01:49,170
secondly it's not always necessary to

38
00:01:54,530 --> 00:01:51,540

reinvent the scientific wheel so to

39
00:01:56,359 --> 00:01:54,540
speak and we can easily apply lessons

40
00:02:00,080 --> 00:01:56,369
from Earth climate research to other

41
00:02:01,670 --> 00:02:00,090
planets so with that I'll say that my

42
00:02:03,709 --> 00:02:01,680
research is primarily concerned with the

43
00:02:06,109 --> 00:02:03,719
micro physics of clouds which is just a

44
00:02:08,660 --> 00:02:06,119
fancy way of saying how do we determine

45
00:02:11,320 --> 00:02:08,670
where clouds form in the atmosphere and

46
00:02:13,720 --> 00:02:11,330
at what rate they form

47
00:02:16,630 --> 00:02:13,730
and if there is one thing I could have

48
00:02:18,370 --> 00:02:16,640
you take away from this it's that in

49
00:02:20,980 --> 00:02:18,380
almost all environmental conditions

50
00:02:23,370 --> 00:02:20,990
clouds form heterogeneous Lee which

51
00:02:25,240 --> 00:02:23,380
means water vapor or some other gaseous

52
00:02:27,880 --> 00:02:25,250
component of the atmosphere is

53
00:02:29,980 --> 00:02:27,890
condensing onto a particle that's also

54
00:02:32,110 --> 00:02:29,990
suspended in the same environment and

55
00:02:34,000 --> 00:02:32,120
that's what I'm trying to show here is

56
00:02:36,490 --> 00:02:34,010
we have a particle also called a cloud

57
00:02:40,510 --> 00:02:36,500
condensation nuclei or ice nuclei on

58
00:02:42,610 --> 00:02:40,520
which ambient high water gas can

59
00:02:45,340 --> 00:02:42,620
condense to form a cloud droplet and

60
00:02:50,380 --> 00:02:45,350
then grow to form a larger cloud droplet

61
00:02:52,630 --> 00:02:50,390
on Mars the only known source of ice or

62
00:02:56,740 --> 00:02:52,640
cloud condensation nuclei is surface

63
00:02:58,890 --> 00:02:56,750

mineral dust for those of you who aren't

64
00:03:02,320 --> 00:02:58,900
familiar i'll do a quick cartoon

65
00:03:06,160 --> 00:03:02,330
depiction of the cloud and water cycles

66
00:03:08,290 --> 00:03:06,170
on Mars so you have wind blowing across

67
00:03:10,060 --> 00:03:08,300
the surface if it's sufficiently strong

68
00:03:12,699 --> 00:03:10,070
it induces a process called saltation

69
00:03:15,400 --> 00:03:12,709
which is lost dust particles into the

70
00:03:17,830 --> 00:03:15,410
air at the same time you an exchange of

71
00:03:20,790 --> 00:03:17,840
water vapor seasonally from the polar

72
00:03:25,090 --> 00:03:20,800
caps and on a diurnal time scale from

73
00:03:26,890 --> 00:03:25,100
ground ice and absorbed water now if you

74
00:03:28,180 --> 00:03:26,900
have suspended dust particles in regions

75
00:03:31,180 --> 00:03:28,190
of the atmosphere which are super

76
00:03:33,940 --> 00:03:31,190
saturated with respect to water you get

77
00:03:36,310 --> 00:03:33,950
clouds now this seems pretty neat and

78
00:03:38,740 --> 00:03:36,320
tidy and you may be wondering what I'm

79
00:03:41,560 --> 00:03:38,750
going to talk about for the next six to

80
00:03:43,750 --> 00:03:41,570
seven minutes and it's there's a big

81
00:03:46,780 --> 00:03:43,760
problem and I made the slide red because

82
00:03:49,360 --> 00:03:46,790
it's a big problem and that's when we

83
00:03:51,100 --> 00:03:49,370
look at the model simulations of cloud

84
00:03:53,530 --> 00:03:51,110
formation how closely do they actually

85
00:03:57,280 --> 00:03:53,540
match the observations that we have and

86
00:03:59,259 --> 00:03:57,290
the answer is not very well especially

87
00:04:01,479 --> 00:03:59,269
when we consider the vertical

88
00:04:04,270 --> 00:04:01,489

distribution of water ice clouds in the

89
00:04:08,350 --> 00:04:04,280
atmosphere and these are three examples

90
00:04:11,170 --> 00:04:08,360
of extinction versus altitude plots from

91
00:04:15,340 --> 00:04:11,180
the spycam instrument so what you see on

92
00:04:17,920 --> 00:04:15,350
the bottom is extinct extinction of due

93
00:04:20,740 --> 00:04:17,930
to water ice particles per kilometer

94
00:04:22,640 --> 00:04:20,750
versus altitude from 10 to 70 kilometers

95
00:04:26,120 --> 00:04:22,650
above the surface

96
00:04:29,140 --> 00:04:26,130
and I've put an orangish yellowish line

97
00:04:31,719 --> 00:04:29,150
at 1 e to the negative 4 because that's

98
00:04:34,700 --> 00:04:31,729
significant amounts of extinction and

99
00:04:37,310 --> 00:04:34,710
this top plot is kind of what our models

100
00:04:38,689 --> 00:04:37,320
can reproduce where we have a high

101
00:04:40,790 --> 00:04:38,699
amount of extinctions near the surface

102
00:04:43,670 --> 00:04:40,800
that falls off by about 20 to 30

103
00:04:45,710 --> 00:04:43,680
kilometers but often in these

104
00:04:48,050 --> 00:04:45,720
observations we have higher altitude

105
00:04:51,200 --> 00:04:48,060
cloud layers that are completely absent

106
00:04:52,879 --> 00:04:51,210
from our GCM model simulations and this

107
00:04:54,080 --> 00:04:52,889
can get really bad especially when you

108
00:04:56,330 --> 00:04:54,090
look at this one where you have clouds

109
00:04:59,990 --> 00:04:56,340
up to 70 kilometers above the surface

110
00:05:02,210 --> 00:05:00,000
and the reason for this discrepancy

111
00:05:04,850 --> 00:05:02,220
between model simulations and

112
00:05:06,439 --> 00:05:04,860
observation is actually the main point

113
00:05:10,010 --> 00:05:06,449

about cloud nucleation that I brought up

114
00:05:12,260 --> 00:05:10,020
before which is if you do not have an

115
00:05:14,659 --> 00:05:12,270
ice nuclei population on which to

116
00:05:17,689 --> 00:05:14,669
condense water you won't get any clouds

117
00:05:19,100 --> 00:05:17,699
at all and the current understanding of

118
00:05:21,260 --> 00:05:19,110
the Mars climate says that the only

119
00:05:24,020 --> 00:05:21,270
source of ice nuclei is surface dust

120
00:05:27,230 --> 00:05:24,030
it's really difficult to loft surface

121
00:05:31,730 --> 00:05:27,240
dust multiple scale heights to above 30

122
00:05:33,589 --> 00:05:31,740
kilometers so what do we do we can

123
00:05:36,500 --> 00:05:33,599
actually look to earth as an analog and

124
00:05:38,149 --> 00:05:36,510
look at high altitude clouds and see how

125
00:05:41,779 --> 00:05:38,159
they nucleate on earth and what they

126
00:05:43,730 --> 00:05:41,789
nuclei on so an example here this nice

127
00:05:45,529 --> 00:05:43,740
picture is naturally some clouds which

128
00:05:47,839 --> 00:05:45,539
are serious water ice clouds that form

129
00:05:49,820 --> 00:05:47,849
at the north polar winter which is

130
00:05:52,310 --> 00:05:49,830
really cold region of the earth

131
00:05:55,159 --> 00:05:52,320
atmosphere that's similar to Mars

132
00:05:57,850 --> 00:05:55,169
conditions and what these clubs are

133
00:06:00,379 --> 00:05:57,860
nucleate on nucleating on is actually

134
00:06:01,939 --> 00:06:00,389
micrometeorite ablation by products

135
00:06:04,990 --> 00:06:01,949
which just means the smoke particles

136
00:06:07,219 --> 00:06:05,000
that form when small micrometer

137
00:06:11,420 --> 00:06:07,229
particles impacting the upper atmosphere

138
00:06:13,969 --> 00:06:11,430

burn up and these are some examples I

139
00:06:15,529 --> 00:06:13,979
can find my pointer of micrometer

140
00:06:17,420 --> 00:06:15,539
particles that we've actually captured

141
00:06:19,969 --> 00:06:17,430
in the Earth's atmosphere but there's a

142
00:06:24,290 --> 00:06:19,979
remote signature of this process which

143
00:06:26,719 --> 00:06:24,300
is elevated ionized metals high in the

144
00:06:30,680 --> 00:06:26,729
atmosphere so you see this elevation and

145
00:06:32,750 --> 00:06:30,690
sodium magnesium iron and this signature

146
00:06:34,700 --> 00:06:32,760
has been seen on Mars as well so we have

147
00:06:38,450 --> 00:06:34,710
direct evidence that this micrometer

148
00:06:40,490 --> 00:06:38,460
ablation process is happening on Mars so

149
00:06:42,050 --> 00:06:40,500
the question becomes could these micro

150
00:06:44,120 --> 00:06:42,060
meteorites be responsible for the high

151
00:06:46,490 --> 00:06:44,130
altitude clouds that we see on Mars and

152
00:06:49,570 --> 00:06:46,500
even a broader question tweening takes

153
00:06:52,010 --> 00:06:49,580
consider some process external to a

154
00:06:54,200 --> 00:06:52,020
planetary system to explain a

155
00:06:58,100 --> 00:06:54,210
fundamental aspect of that planet's

156
00:07:00,320 --> 00:06:58,110
climate so to answer this question I've

157
00:07:02,089 --> 00:07:00,330
used the Morris cam karma general

158
00:07:04,790 --> 00:07:02,099
circulation model and this was developed

159
00:07:08,420 --> 00:07:04,800
in partnership between n car and last

160
00:07:11,810 --> 00:07:08,430
and this is kind of just a depiction of

161
00:07:13,129 --> 00:07:11,820
what a GCM is and how it works if you'd

162
00:07:14,420 --> 00:07:13,139
like more information I'm not going to

163
00:07:17,089 --> 00:07:14,430

go into it here but you can always find

164
00:07:20,300 --> 00:07:17,099
me but what we did and this is a nice

165
00:07:22,100 --> 00:07:20,310
artist's rendition we just added 7,500

166
00:07:23,719 --> 00:07:22,110
tons of microbe you direct material

167
00:07:27,649 --> 00:07:23,729
which sounds like a lot but as a

168
00:07:31,940 --> 00:07:27,659
fraction of what is what we get on earth

169
00:07:34,969 --> 00:07:31,950
every year so 7,500 tons per year and we

170
00:07:38,019 --> 00:07:34,979
just distributed it evenly in time and

171
00:07:41,180 --> 00:07:38,029
in space across the top of the model and

172
00:07:43,159 --> 00:07:41,190
i'll show you some quick results so here

173
00:07:44,420 --> 00:07:43,169
again it's a similar I've apologized for

174
00:07:46,879 --> 00:07:44,430
all the lines I'll try to walk through

175
00:07:50,330 --> 00:07:46,889
it again we have extinction on the

176
00:07:52,310 --> 00:07:50,340
bottom and the 10 to the my or one to

177
00:07:54,140 --> 00:07:52,320
the minus four is marked by that line

178
00:07:57,890 --> 00:07:54,150
again and again altitude on the y axis

179
00:08:00,620 --> 00:07:57,900
from 0 to 70 and these are just zonally

180
00:08:02,269 --> 00:08:00,630
averaged latitude bands but what you'll

181
00:08:04,610 --> 00:08:02,279
see is when we have new micro meteorites

182
00:08:06,320 --> 00:08:04,620
we do get some elevated layers but

183
00:08:10,490 --> 00:08:06,330
they're all the extinction is really low

184
00:08:13,100 --> 00:08:10,500
and most of the high extinctions fall

185
00:08:15,170 --> 00:08:13,110
off below 20 or 30 kilometers but the

186
00:08:18,200 --> 00:08:15,180
second we add this micro meteoritic

187
00:08:21,500 --> 00:08:18,210
source you get elevated extinctions

188
00:08:24,290 --> 00:08:21,510

about 30 but also these enhancements at

189
00:08:26,329 --> 00:08:24,300
high altitude around 50 and above and

190
00:08:28,939 --> 00:08:26,339
again this is a zonal average so we're

191
00:08:31,390 --> 00:08:28,949
kind of smashing out some of these

192
00:08:33,769 --> 00:08:31,400
really high altitude interesting layers

193
00:08:35,659 --> 00:08:33,779
but the takeaway point is when we add

194
00:08:39,740 --> 00:08:35,669
micrometeorites we really enhance cloud

195
00:08:42,239 --> 00:08:39,750
extinctions at all latitudes and at all

196
00:08:50,079 --> 00:08:47,019
secondly this is there is an observed

197
00:08:53,800 --> 00:08:50,089
seasonal cycle in the hay stop the haze

198
00:08:55,600 --> 00:08:53,810
top is just basically the highest

199
00:08:58,410 --> 00:08:55,610
altitude in your atmosphere where you

200
00:09:01,150 --> 00:08:58,420
have significant extinction from clouds

201
00:09:03,489 --> 00:09:01,160
there's a basic seasonal pattern that we

202
00:09:07,379 --> 00:09:03,499
see that corresponds with the orbit of

203
00:09:10,869 --> 00:09:07,389
Mars we're early in the year which is

204
00:09:12,939 --> 00:09:10,879
here when we're in northern summer or

205
00:09:15,970 --> 00:09:12,949
southern or northern winter southern

206
00:09:17,679 --> 00:09:15,980
summer the haze top is low and then when

207
00:09:20,369 --> 00:09:17,689
we warm up in the intense southern

208
00:09:23,619 --> 00:09:20,379
summer the haze top Rises but the

209
00:09:25,900 --> 00:09:23,629
addition of micrometeorites generally

210
00:09:28,929 --> 00:09:25,910
raises the haze top globally and you

211
00:09:32,980 --> 00:09:28,939
also get this interesting enhancement in

212
00:09:35,110 --> 00:09:32,990
the haze top / polar winter and this

213
00:09:36,730 --> 00:09:35,120

corresponds with some observations and

214
00:09:39,249 --> 00:09:36,740
there's not a really good there's no

215
00:09:42,340 --> 00:09:39,259
global coverage of the haze top so I

216
00:09:45,400 --> 00:09:42,350
don't have a good data comparison but

217
00:09:51,160 --> 00:09:45,410
you can maybe believe me when I say this

218
00:09:52,629 --> 00:09:51,170
is comparable so finally what's

219
00:09:54,759 --> 00:09:52,639
interesting to note is when we change

220
00:09:56,740 --> 00:09:54,769
the distribution of ice nuclei it's not

221
00:10:00,670 --> 00:09:56,750
just where the clouds are it also

222
00:10:03,119 --> 00:10:00,680
influences how we r where the clouds are

223
00:10:05,710 --> 00:10:03,129
in across the latitudes and longitudes

224
00:10:08,049 --> 00:10:05,720
also how high they are in the atmosphere

225
00:10:12,249 --> 00:10:08,059
and the radiative impact of these clouds

226
00:10:14,290 --> 00:10:12,259
which can be really large so to speak

227
00:10:16,840 --> 00:10:14,300
very generally if you have fewer ice

228
00:10:19,509 --> 00:10:16,850
nuclei you get larger cloud particles as

229
00:10:21,879 --> 00:10:19,519
you increase the number of ice nuclei

230
00:10:23,530 --> 00:10:21,889
you get smaller cloud particles and this

231
00:10:25,360 --> 00:10:23,540
changes the way that it interacts with

232
00:10:29,290 --> 00:10:25,370
radiation so when you have large

233
00:10:30,999 --> 00:10:29,300
particles more of the light gets down to

234
00:10:33,129 --> 00:10:31,009
the surface and less is reflected to

235
00:10:35,619 --> 00:10:33,139
space so that can have obviously a big

236
00:10:37,809 --> 00:10:35,629
impact on your climate also the side of

237
00:10:40,150 --> 00:10:37,819
these particles changes a lifetime that

238
00:10:42,489 --> 00:10:40,160

cloud stay in the atmosphere and whether

239
00:10:45,460 --> 00:10:42,499
you snow immediately upon falling or can

240
00:10:47,679 --> 00:10:45,470
move water and precipitation to lower

241
00:10:49,689 --> 00:10:47,689
latitudes so if you look at the amount

242
00:10:52,210 --> 00:10:49,699
of water in the atmosphere versus time

243
00:10:55,330 --> 00:10:52,220
when you add these micro meteorites you

244
00:10:59,310 --> 00:10:55,340
can get water to reach to

245
00:11:03,550 --> 00:11:01,660
so just briefly closed by talking about

246
00:11:06,160 --> 00:11:03,560
the Mars paleoclimate and how this

247
00:11:08,380 --> 00:11:06,170
research applies to it and this is kind

248
00:11:10,360 --> 00:11:08,390
of the big question in paleo climate

249
00:11:13,240 --> 00:11:10,370
right now which is what martyrs warm and

250
00:11:15,070 --> 00:11:13,250
wet or cold and icy so this is just a

251
00:11:19,600 --> 00:11:15,080
depiction of those two competing

252
00:11:22,420 --> 00:11:19,610
hypotheses of early Mars and what we

253
00:11:24,460 --> 00:11:22,430
found in very preliminary research is

254
00:11:27,850 --> 00:11:24,470
that having high altitude clouds that

255
00:11:29,920 --> 00:11:27,860
are large with large particle sizes you

256
00:11:33,100 --> 00:11:29,930
can sustain a warm Martian climate

257
00:11:37,750 --> 00:11:33,110
without artificially enhancing the

258
00:11:39,550 --> 00:11:37,760
atmosphere by adding different just

259
00:11:42,010 --> 00:11:39,560
different chemical components that we

260
00:11:44,890 --> 00:11:42,020
don't see real evidence of being there

261
00:11:46,960 --> 00:11:44,900
so with this new model we can look at

262
00:11:49,480 --> 00:11:46,970
how the vertical distribution of this

263
00:11:52,000 --> 00:11:49,490

these water out water ice clouds

264
00:11:54,100 --> 00:11:52,010
influence the radiative environment and

265
00:11:56,680 --> 00:11:54,110
also look at how the particle size and

266
00:11:57,940 --> 00:11:56,690
distribution will impact that so

267
00:12:01,120 --> 00:11:57,950
hopefully that can get a little more

268
00:12:03,940 --> 00:12:01,130
information so just to close I'll try to

269
00:12:05,770 --> 00:12:03,950
summarize remember clouds form

270
00:12:07,750 --> 00:12:05,780
heterogeneous ly so you need an ice

271
00:12:10,450 --> 00:12:07,760
nuclei population to form clouds or else

272
00:12:12,580 --> 00:12:10,460
you just get a supersaturated atmosphere

273
00:12:14,980 --> 00:12:12,590
so the problem with the current

274
00:12:17,560 --> 00:12:14,990
generation of Mars general circulation

275
00:12:19,540 --> 00:12:17,570
models that we can't loft ice nuclei to

276
00:12:22,000 --> 00:12:19,550
high enough altitudes to reproduce the

277
00:12:24,280 --> 00:12:22,010
clouds that we actually observe but on

278
00:12:26,530 --> 00:12:24,290
earth high altitude clouds nucleate on

279
00:12:28,180 --> 00:12:26,540
micro meteorites so we tried to look at

280
00:12:31,090 --> 00:12:28,190
that and see if we could reproduce these

281
00:12:32,410 --> 00:12:31,100
high clouds and as it looks now we can

282
00:12:35,350 --> 00:12:32,420
so this is really promising an

283
00:12:37,270 --> 00:12:35,360
interesting quirk so if you have any

284
00:12:39,310 --> 00:12:37,280
questions this is since you're all

285
00:12:42,250 --> 00:12:39,320
talking about Iceland this is me at one

286
00:12:44,950 --> 00:12:42,260
of the Mars analog sites and so you can

287
00:12:46,240 --> 00:12:44,960
remember who i am and find you later but

288
00:12:51,769 --> 00:12:46,250

you can also follow me on twitter or

289
00:13:05,519 --> 00:13:02,220
question lots of questions um so you

290
00:13:08,430 --> 00:13:05,529
mentioned that the the tonnage of

291
00:13:10,320 --> 00:13:08,440
micrometeorites was fairly low how did

292
00:13:13,230 --> 00:13:10,330
you come up with the number for that as

293
00:13:16,920 --> 00:13:13,240
this is just an extrapolation basically

294
00:13:18,210 --> 00:13:16,930
by what we from Earth to the Mars orbit

295
00:13:22,500 --> 00:13:18,220
based on what we know of the

296
00:13:24,360 --> 00:13:22,510
distribution of microbial in the current

297
00:13:26,579 --> 00:13:24,370
solar system but obviously this is going

298
00:13:28,139 --> 00:13:26,589
to change with time so if we rewind the

299
00:13:30,230 --> 00:13:28,149
clock to paleoclimate it should be

300
00:13:33,360 --> 00:13:30,240
different and there's actually a lot of

301
00:13:35,930 --> 00:13:33,370
complexity with the distribution of

302
00:13:38,130 --> 00:13:35,940
meteorite material with season

303
00:13:40,050 --> 00:13:38,140
potentially so there's a lot of work to

304
00:13:42,240 --> 00:13:40,060
do here but we've done different

305
00:13:43,620 --> 00:13:42,250
simulations that test kind of

306
00:13:46,680 --> 00:13:43,630
parameterize and go through a space of

307
00:13:51,150 --> 00:13:46,690
this and do 02 / like one hundred fifty

308
00:13:53,220 --> 00:13:51,160
percent of that number I have two

309
00:13:56,970 --> 00:13:53,230
questions so on the slide where you had

310
00:14:01,620 --> 00:13:56,980
the images of the different micro dust

311
00:14:03,660 --> 00:14:01,630
particles micrometers yes um so yeah so

312
00:14:06,120 --> 00:14:03,670
the scale bar you say 50 microns is that

313
00:14:07,860 --> 00:14:06,130

one parcours at multiple at clump

314
00:14:10,710 --> 00:14:07,870
together that's the conglomerate these

315
00:14:12,630 --> 00:14:10,720
are really small and usually that might

316
00:14:15,680 --> 00:14:12,640
be actually a particle that was captured

317
00:14:19,050 --> 00:14:15,690
high in the atmosphere prior to ablation

318
00:14:20,449 --> 00:14:19,060
it in the Earth's atmosphere most of

319
00:14:22,920 --> 00:14:20,459
these are going to ablate completely

320
00:14:26,940 --> 00:14:22,930
unless they're pretty large and then

321
00:14:30,829 --> 00:14:26,950
coagulate to really like point 01 micron

322
00:14:33,269 --> 00:14:30,839
size particles are smaller yeah okay um

323
00:14:34,800 --> 00:14:33,279
another question so in your models do

324
00:14:36,510 --> 00:14:34,810
you ever take into account the different

325
00:14:38,850 --> 00:14:36,520
mechanisms of heterogeneous ice

326
00:14:41,160 --> 00:14:38,860
nucleation because when like

327
00:14:42,780 --> 00:14:41,170
depositional isolation happen like

328
00:14:45,420 --> 00:14:42,790
higher in the atmosphere versus like

329
00:14:47,490 --> 00:14:45,430
what's nice about Mars is the entire and

330
00:14:51,870 --> 00:14:47,500
the entire atmosphere is really really

331
00:14:54,240 --> 00:14:51,880
cold so basically the same nucleation

332
00:14:55,500 --> 00:14:54,250
process that you'd see high in the

333
00:14:57,660 --> 00:14:55,510
Earth's atmosphere is basically

334
00:14:59,460 --> 00:14:57,670
everywhere which is so if anyone is

335
00:15:05,970 --> 00:14:59,470
earned earth scientists here if Mars can

336
00:15:12,699 --> 00:15:09,519
um so when you're looking at the like

337
00:15:15,040 --> 00:15:12,709
paleo climate of Mars do you I take into

338
00:15:18,340 --> 00:15:15,050

consideration that that the Sun should

339
00:15:21,879 --> 00:15:18,350
be fainter early sources yeah I mean

340
00:15:24,129 --> 00:15:21,889
that's basically why these this icy

341
00:15:26,650 --> 00:15:24,139
highlands hypothesis originated because

342
00:15:29,040 --> 00:15:26,660
with I mean you can't even really get

343
00:15:31,150 --> 00:15:29,050
Mars that warm now and if you reduce the

344
00:15:34,210 --> 00:15:31,160
luminosity of the sun by that much it's

345
00:15:40,780 --> 00:15:34,220
really difficult to warm the surface

346
00:15:43,000 --> 00:15:40,790
consistently I was wondering how long

347
00:15:46,210 --> 00:15:43,010
you expect these clouds to stay

348
00:15:49,480 --> 00:15:46,220
suspended it really depends on where

349
00:15:52,180 --> 00:15:49,490
they are the polar clouds for example

350
00:15:53,829 --> 00:15:52,190
it's pretty super saturated in that

351
00:15:56,800 --> 00:15:53,839
region so they can grow really quickly

352
00:15:59,610 --> 00:15:56,810
and then we get snowfall very quickly in

353
00:16:02,819 --> 00:15:59,620
that region but if you change the

354
00:16:06,490 --> 00:16:02,829
parameters ations of the nucleation

355
00:16:10,439 --> 00:16:06,500
process they can be smaller and stay

356
00:16:12,430 --> 00:16:10,449
suspended so we see clouds that

357
00:16:14,889 --> 00:16:12,440
originated near the poles and they're

358
00:16:17,860 --> 00:16:14,899
able to kind of drift down into the

359
00:16:20,439 --> 00:16:17,870
equatorial regions okay and then one

360
00:16:21,880 --> 00:16:20,449
other comment was I know in exoplanets

361
00:16:23,980 --> 00:16:21,890
there's high altitude Hayes's that

362
00:16:26,980 --> 00:16:23,990
they're blocking give any insight into

363
00:16:30,730 --> 00:16:26,990

this mechanism as a possible explanation

364
00:16:34,269 --> 00:16:30,740
for that no but I can wildly speculate

365
00:16:36,910 --> 00:16:34,279
oh it should be to say that there's no

366
00:16:40,530 --> 00:16:36,920
reason why this micrometeoroid material

367
00:16:43,360 --> 00:16:40,540
would be only in our solar system so I

368
00:16:47,350 --> 00:16:43,370
think it'd be potentially important

369
00:16:49,420 --> 00:16:47,360
factor to consider and I think just as a

370
00:16:51,100 --> 00:16:49,430
point that we need to we can't just look

371
00:16:54,340 --> 00:16:51,110
at these planets in isolation and there

372
00:16:56,199 --> 00:16:54,350
may be other stuff going on well i'm at

373
00:16:58,720 --> 00:16:56,209
mistis do we know the green size

374
00:17:08,559 --> 00:16:58,730
distribution of dust partly goes on Mars

375
00:17:11,500 --> 00:17:08,569
doesn't matter um yes and no we know a

376
00:17:13,780 --> 00:17:11,510
fair amount about low atmosphere grain

377
00:17:15,769 --> 00:17:13,790
sizes we know that there's a population

378
00:17:17,779 --> 00:17:15,779
an extremely small part of

379
00:17:20,329 --> 00:17:17,789
kohl's at high altitudes but it's

380
00:17:23,359 --> 00:17:20,339
difficult to tell if this is dust or ice

381
00:17:25,399 --> 00:17:23,369
so it's kind of hard to decon volute

382
00:17:27,549 --> 00:17:25,409
that and also these grain size

383
00:17:29,629 --> 00:17:27,559
retrievals are based on usually two

384
00:17:36,409 --> 00:17:29,639
wavelengths that most and a lot of

385
00:17:38,690 --> 00:17:36,419
assumptions like how much let me come in

386
00:17:40,129 --> 00:17:38,700
you guys got into the air in the first

387
00:17:42,409 --> 00:17:40,139
yeah I definitely I mean if you have a

388
00:17:44,570 --> 00:17:42,419

much larger particle than expected it's

389
00:17:47,299 --> 00:17:44,580
going to blate with the less at lower

390
00:17:50,570 --> 00:17:47,309
altitudes or less efficiently which

391
00:17:53,320 --> 00:17:50,580
would change the distribution but this

392
00:17:55,789 --> 00:17:53,330
kind of exploratory at this point and

393
00:17:57,200 --> 00:17:55,799
there's a lot of other parameters ations

394
00:17:59,149 --> 00:17:57,210
that we'd probably have to do first but

395
00:18:02,539 --> 00:17:59,159
that's kind of touched in when we change

396
00:18:06,589 --> 00:18:02,549
the amount of meteor material one more

397
00:18:09,799 --> 00:18:06,599
quick question so I'm just so how do you

398
00:18:12,799 --> 00:18:09,809
determine how to distribute the the

399
00:18:15,769 --> 00:18:12,809
micro meteorites spatially in your model

400
00:18:17,989 --> 00:18:15,779
um well right now we just kind of follow

401
00:18:20,930 --> 00:18:17,999
Earth's example and it's pretty uniform

402
00:18:23,619 --> 00:18:20,940
across latitudes and longitudes on earth

403
00:18:27,369 --> 00:18:23,629
and there's some suggestion that there's

404
00:18:29,509 --> 00:18:27,379
distributions in time that vary and

405
00:18:31,999 --> 00:18:29,519
there's definitely a distribution

406
00:18:34,070 --> 00:18:32,009
vertically where you see an enhancement

407
00:18:35,959 --> 00:18:34,080
right at the layer of peak or the

408
00:18:38,419 --> 00:18:35,969
altitude of peak ablation but that's

409
00:18:40,629 --> 00:18:38,429
actually above our model top so we've

410
00:18:44,209 --> 00:18:40,639
kind of skirted around that and just

411
00:18:45,709 --> 00:18:44,219
place it all right at the top but that's