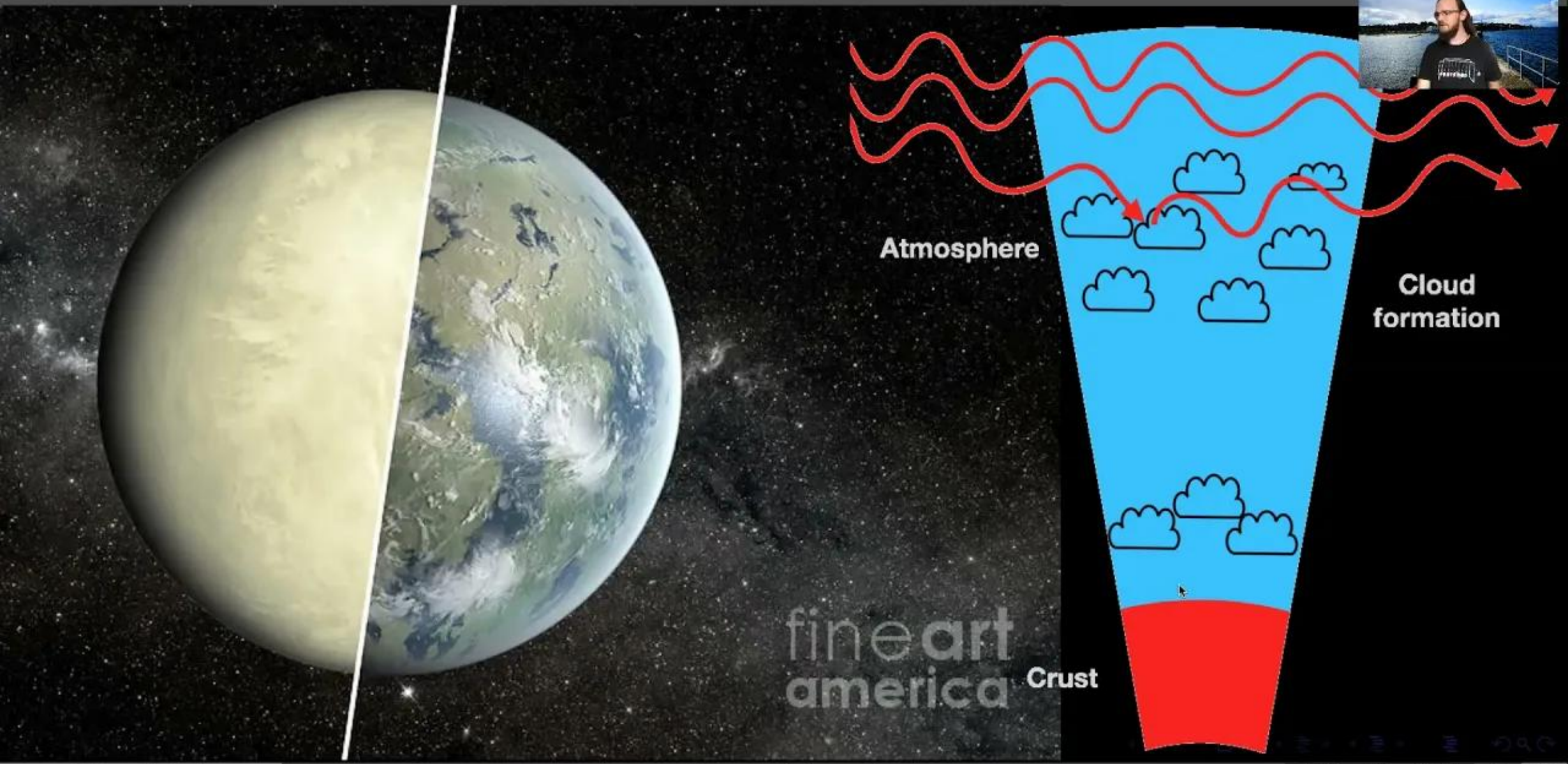
Does a planet have liquid water?



1
00:00:05,510 --> 00:00:03,990
hi

2
00:00:07,590 --> 00:00:05,520
my name is oliver herbert and i'm

3
00:00:09,270 --> 00:00:07,600
presenting to you today the work on

4
00:00:12,070 --> 00:00:09,280
atmospheres of rocky accident that i've

5
00:00:14,910 --> 00:00:12,080
been doing during my phd in snandrus

6
00:00:16,550 --> 00:00:14,920
so the main one of the main questions of

7
00:00:20,230 --> 00:00:16,560
astrobiology is whether

8
00:00:20,950 --> 00:00:20,240
planet itself is dry has no liquid water

9
00:00:23,269 --> 00:00:20,960
at the surface

10
00:00:23,990 --> 00:00:23,279
or whether it does have actual water at

11
00:00:26,950 --> 00:00:24,000
the surface

12
00:00:28,710 --> 00:00:26,960
so that life as we know it can thrive so

13
00:00:32,630 --> 00:00:28,720

the big question is how can we actually

14
00:00:35,110 --> 00:00:32,640
detect this from our own earth

15
00:00:36,310 --> 00:00:35,120
how can we tell that on other planets

16
00:00:38,470 --> 00:00:36,320
and therefore

17
00:00:40,229 --> 00:00:38,480
one has to understand that during for

18
00:00:41,910 --> 00:00:40,239
example transmission spectroscopy

19
00:00:43,990 --> 00:00:41,920
one is actually probing the high parts

20
00:00:45,510 --> 00:00:44,000
of the atmosphere that when the light is

21
00:00:48,950 --> 00:00:45,520
traveling through the atmosphere

22
00:00:51,189 --> 00:00:48,960
we actually do see only the composition

23
00:00:53,110 --> 00:00:51,199
of the high parts of the atmosphere and

24
00:00:54,229 --> 00:00:53,120
if we are fortunate at some point

25
00:00:55,670 --> 00:00:54,239
in the future with future

26
00:00:56,709 --> 00:00:55,680
instrumentations we get some scattering

27
00:00:59,110 --> 00:00:56,719
effects from

28
00:00:59,750 --> 00:00:59,120
some particular um cloud condensates and

29
00:01:02,790 --> 00:00:59,760
those

30
00:01:05,030 --> 00:01:02,800
we can then um analyze and

31
00:01:07,109 --> 00:01:05,040
tell which actual condensates that is

32
00:01:08,950 --> 00:01:07,119
but that is not really

33
00:01:11,510 --> 00:01:08,960
exactly the crust composition the cross

34
00:01:14,070 --> 00:01:11,520
condition can be slightly different

35
00:01:15,590 --> 00:01:14,080
and that is what i am working on and

36
00:01:17,109 --> 00:01:15,600
what i'm going to present today

37
00:01:18,870 --> 00:01:17,119
and in order to do so we need to

38
00:01:21,109 --> 00:01:18,880

understand that

39
00:01:21,990 --> 00:01:21,119
the crust and the atmosphere there are

40
00:01:25,030 --> 00:01:22,000
many

41
00:01:26,630 --> 00:01:25,040
lings for them and especially

42
00:01:28,469 --> 00:01:26,640
at the very bottom where the crust is

43
00:01:29,830 --> 00:01:28,479
outgassing into the atmosphere there can

44
00:01:31,510 --> 00:01:29,840
be volcanism there can be

45
00:01:32,950 --> 00:01:31,520
plate tectonics which actually drive

46
00:01:34,710 --> 00:01:32,960
some parts of the er

47
00:01:36,870 --> 00:01:34,720
from the exposed rock towards the mantle

48
00:01:38,310 --> 00:01:36,880
again chemical weathering can affect can

49
00:01:39,109 --> 00:01:38,320
have some effects from the atmosphere

50
00:01:41,429 --> 00:01:39,119
onto the

51
00:01:42,230 --> 00:01:41,439
rock composition then higher up in the

52
00:01:43,910 --> 00:01:42,240
atmosphere

53
00:01:46,710 --> 00:01:43,920
where we do have potential cloud

54
00:01:50,630 --> 00:01:46,720
formation the clouds are depleting the

55
00:01:53,670 --> 00:01:50,640
rest of the uh the elements that are

56
00:01:55,109 --> 00:01:53,680
used up in the clouds so that the

57
00:01:55,990 --> 00:01:55,119
element composition below and above the

58
00:01:57,670 --> 00:01:56,000
clouds are different

59
00:01:59,510 --> 00:01:57,680
atmospheric loss parts of atmosphere the

60
00:02:01,190 --> 00:01:59,520
atmosphere can be lost through space

61
00:02:03,670 --> 00:02:01,200
and then last but definitely not least

62
00:02:04,069 --> 00:02:03,680
photochemistry stellar radiation cosmic

63
00:02:07,190 --> 00:02:04,079

rays

64
00:02:09,270 --> 00:02:07,200
can change the atmospheric composition

65
00:02:10,309 --> 00:02:09,280
the chemical buildup of the atmosphere

66
00:02:11,750 --> 00:02:10,319
however

67
00:02:13,110 --> 00:02:11,760
at the beginning of this talk i would

68
00:02:14,550 --> 00:02:13,120
only focus on the atmosphere crust

69
00:02:15,510 --> 00:02:14,560
interaction at the very bottom of this

70
00:02:17,670 --> 00:02:15,520
atmosphere

71
00:02:18,550 --> 00:02:17,680
and then provide insights the surface

72
00:02:19,750 --> 00:02:18,560
conditions and then

73
00:02:21,990 --> 00:02:19,760
set the preconditions for cloud

74
00:02:23,589 --> 00:02:22,000
information later in the talk

75
00:02:25,350 --> 00:02:23,599
the model i'm using is an equilibrium

76
00:02:27,190 --> 00:02:25,360
chemistry model

77
00:02:28,949 --> 00:02:27,200
you with an equilibrium conversation

78
00:02:31,270 --> 00:02:28,959
called gigi chem by peter weitge

79
00:02:32,550 --> 00:02:31,280
my supervisor and it basically takes a

80
00:02:35,110 --> 00:02:32,560
given set of elements

81
00:02:36,470 --> 00:02:35,120
the total element abundances so given

82
00:02:37,030 --> 00:02:36,480
amount of hydrogen given amount of

83
00:02:39,190 --> 00:02:37,040
carbon

84
00:02:40,869 --> 00:02:39,200
nitrogen oxygen but also with elements

85
00:02:44,150 --> 00:02:40,879
like calcium titanium

86
00:02:45,190 --> 00:02:44,160
or so and puts them into one big culture

87
00:02:45,830 --> 00:02:45,200
and they're given pressure given

88
00:02:47,670 --> 00:02:45,840

temperature

89
00:02:49,589 --> 00:02:47,680
and then on the basis of minimization of

90
00:02:50,869 --> 00:02:49,599
gibbs free energy calculates what's most

91
00:02:52,869 --> 00:02:50,879
stable in the gas phase

92
00:02:54,710 --> 00:02:52,879
there are no over no supersaturated

93
00:02:57,990 --> 00:02:54,720
molecules in the gas phase

94
00:03:01,190 --> 00:02:58,000
and we allow that or we force that by

95
00:03:01,990 --> 00:03:01,200
actually having condensation and these

96
00:03:05,670 --> 00:03:02,000
condensates

97
00:03:09,030 --> 00:03:05,680
are then building up the crust of the

98
00:03:12,229 --> 00:03:09,040
of the planet that we have so

99
00:03:13,110 --> 00:03:12,239
one of the big uh components to uh to

100
00:03:14,710 --> 00:03:13,120
vary here

101
00:03:16,229 --> 00:03:14,720
is the total element abundance and

102
00:03:18,470 --> 00:03:16,239
that's what i show you here

103
00:03:19,430 --> 00:03:18,480
in this plot on the right-hand side

104
00:03:22,070 --> 00:03:19,440
where we have on the

105
00:03:24,229 --> 00:03:22,080
on the y-axis the element abundance

106
00:03:27,589 --> 00:03:24,239
relative to silica and on the x-axis

107
00:03:30,149 --> 00:03:27,599
um different uh elements and we see when

108
00:03:32,390 --> 00:03:30,159
we compare the squares and the diamonds

109
00:03:33,750 --> 00:03:32,400
the ci contract left over up from the

110
00:03:35,430 --> 00:03:33,760
formation of the solar system which is

111
00:03:36,869 --> 00:03:35,440
particularly enriched in the volatile

112
00:03:38,949 --> 00:03:36,879
the gas loving

113
00:03:41,830 --> 00:03:38,959

um elements like hydrogen carbon

114
00:03:44,070 --> 00:03:41,840
nitrogen but also sulfur or phosphorus

115
00:03:45,030 --> 00:03:44,080
in comparison to the bulk silicate earth

116
00:03:47,589 --> 00:03:45,040
which is earth

117
00:03:48,229 --> 00:03:47,599
without its core and counting all of the

118
00:03:52,309 --> 00:03:48,239
elements

119
00:03:54,949 --> 00:03:52,319
aluminium

120
00:03:55,509 --> 00:03:54,959
or calcium are very very similar for

121
00:03:57,830 --> 00:03:55,519
those

122
00:03:59,350 --> 00:03:57,840
but they have different effects on the

123
00:04:00,789 --> 00:03:59,360
resulting atmosphere

124
00:04:03,589 --> 00:04:00,799
and that's what i show you here in this

125
00:04:06,390 --> 00:04:03,599
plot where i'll walk you through it now

126
00:04:08,550 --> 00:04:06,400
so it's 100 bar atmosphere and

127
00:04:09,589 --> 00:04:08,560
temperature range from 100 to 5000

128
00:04:11,750 --> 00:04:09,599
kelvin

129
00:04:14,070 --> 00:04:11,760
and on the y-axis we have the molecular

130
00:04:15,110 --> 00:04:14,080
abundance of the gas species for the

131
00:04:17,430 --> 00:04:15,120
very high temperatures

132
00:04:19,349 --> 00:04:17,440
we vaporize the rock we have metal

133
00:04:21,590 --> 00:04:19,359
oxides dominating the atmosphere

134
00:04:22,390 --> 00:04:21,600
and then for lower temperatures water

135
00:04:25,189 --> 00:04:22,400
sulfur

136
00:04:26,310 --> 00:04:25,199
dioxide and carbon dioxide are the most

137
00:04:29,030 --> 00:04:26,320
important

138
00:04:31,189 --> 00:04:29,040

parts of the atmosphere and they then

139
00:04:34,070 --> 00:04:31,199
condense out at different points

140
00:04:35,749 --> 00:04:34,080
leaving nitrogen behind for the ci

141
00:04:36,790 --> 00:04:35,759
contract this image is relatively the

142
00:04:38,870 --> 00:04:36,800
same

143
00:04:39,909 --> 00:04:38,880
metal oxides at the high temperature

144
00:04:41,590 --> 00:04:39,919
range and then

145
00:04:43,990 --> 00:04:41,600
water carbon dioxide and nitrogen

146
00:04:45,990 --> 00:04:44,000
leaving behind but there's also methane

147
00:04:48,550 --> 00:04:46,000
h2co

148
00:04:49,990 --> 00:04:48,560
and atomic hydrogen and that is called

149
00:04:52,790 --> 00:04:50,000
because there's just so much more

150
00:04:56,390 --> 00:04:52,800
volatiles in this model

151
00:04:58,310 --> 00:04:56,400
if we now want to investigate where the

152
00:04:59,909 --> 00:04:58,320
hydrogen itself goes where does the

153
00:05:01,990 --> 00:04:59,919
hydrogen go

154
00:05:04,150 --> 00:05:02,000
and that's what i show you here in the

155
00:05:07,350 --> 00:05:04,160
range of thousand two hundred kelvin

156
00:05:08,310 --> 00:05:07,360
where the water gas is getting low and

157
00:05:10,150 --> 00:05:08,320
lower in abundance

158
00:05:11,430 --> 00:05:10,160
and all of the hydrogen is forming soda

159
00:05:13,830 --> 00:05:11,440
fluoropythology

160
00:05:15,110 --> 00:05:13,840
those are two phyllosilicates and so uh

161
00:05:16,870 --> 00:05:15,120
so hydrated rocks

162
00:05:18,950 --> 00:05:16,880
that actually incorporate oh into the

163
00:05:21,110 --> 00:05:18,960

lattice structure

164
00:05:23,110 --> 00:05:21,120
and if we look at the ci chondrite model

165
00:05:24,469 --> 00:05:23,120
we see that there's a huge variety of

166
00:05:26,390 --> 00:05:24,479
different phyllosilicates

167
00:05:28,710 --> 00:05:26,400
that incorporate a lot of the hydrogen

168
00:05:31,510 --> 00:05:28,720
but there's still enough hydrogen left

169
00:05:32,629 --> 00:05:31,520
that we can actually form liquid water

170
00:05:33,909 --> 00:05:32,639
over these

171
00:05:35,990 --> 00:05:33,919
phyllosilicates that need to be

172
00:05:38,310 --> 00:05:36,000
saturated we can also

173
00:05:39,189 --> 00:05:38,320
force our bulk silicate earth model in

174
00:05:41,510 --> 00:05:39,199
order to

175
00:05:43,350 --> 00:05:41,520
actually form water and by that we can

176
00:05:44,230 --> 00:05:43,360
do by increasing hydrogen and oxygen

177
00:05:46,230 --> 00:05:44,240
abundances

178
00:05:47,749 --> 00:05:46,240
and then we can saturate the

179
00:05:48,550 --> 00:05:47,759
phyllosilicates and then on top of that

180
00:05:49,990 --> 00:05:48,560
we will have

181
00:05:53,029 --> 00:05:50,000
the liquid water because the phyllis

182
00:05:56,390 --> 00:05:53,039
liquids are just more much more stable

183
00:05:58,070 --> 00:05:56,400
so this was only the atmosphere cross

184
00:05:58,950 --> 00:05:58,080
interaction layer an atmosphere is more

185
00:06:00,550 --> 00:05:58,960
than that

186
00:06:02,390 --> 00:06:00,560
and it's also more than just the

187
00:06:03,990 --> 00:06:02,400
troposphere but for this part

188
00:06:05,909 --> 00:06:04,000

i'm talking about the troposphere is the

189
00:06:06,550 --> 00:06:05,919
lower part of the atmosphere where the

190
00:06:08,309 --> 00:06:06,560
pressure

191
00:06:09,670 --> 00:06:08,319
over the temperature is just decreasing

192
00:06:11,990 --> 00:06:09,680
with the pressure

193
00:06:12,950 --> 00:06:12,000
as shown on the plots here at the bottom

194
00:06:15,350 --> 00:06:12,960
left here

195
00:06:17,430 --> 00:06:15,360
and as we build our hydrostatic

196
00:06:19,350 --> 00:06:17,440
polytropic atmosphere from bottom to top

197
00:06:21,430 --> 00:06:19,360
we solve chemical phase equilibrium in

198
00:06:23,110 --> 00:06:21,440
every atmospheric layer

199
00:06:25,270 --> 00:06:23,120
and every time when there's a condensate

200
00:06:27,990 --> 00:06:25,280
stable we take the condensate

201
00:06:29,350 --> 00:06:28,000
take them out interpret them as a

202
00:06:31,510 --> 00:06:29,360
thermally stable cloud

203
00:06:33,990 --> 00:06:31,520
and only take the gas phase as the total

204
00:06:35,909 --> 00:06:34,000
element abundance of the layer above

205
00:06:38,150 --> 00:06:35,919
and with that we actually do build our

206
00:06:41,270 --> 00:06:38,160
atmosphere that is actually depleted

207
00:06:43,110 --> 00:06:41,280
in those condensates that are taken out

208
00:06:44,550 --> 00:06:43,120
that formed clouds there's no kinetic

209
00:06:45,670 --> 00:06:44,560
cloud formation in here that's the next

210
00:06:49,029 --> 00:06:45,680
step to do

211
00:06:52,870 --> 00:06:49,039
but this is to investigate what is

212
00:06:55,830 --> 00:06:52,880
thermally stable the fact of this for

213
00:06:57,430 --> 00:06:55,840

the element for the molecular abundances

214
00:06:58,790 --> 00:06:57,440
in the atmosphere can be seen in this

215
00:07:02,629 --> 00:06:58,800
spot on the right hand side

216
00:07:05,029 --> 00:07:02,639
being the actual molecular abundance

217
00:07:06,469 --> 00:07:05,039
at the bottom of the atmosphere and then

218
00:07:07,189 --> 00:07:06,479
going to the left is to the top of the

219
00:07:11,510 --> 00:07:07,199
atmosphere

220
00:07:13,510 --> 00:07:11,520
the beginning and especially we see that

221
00:07:15,430 --> 00:07:13,520
water the blue line and carbon dioxide

222
00:07:16,070 --> 00:07:15,440
are decreasing significantly throughout

223
00:07:17,830 --> 00:07:16,080
the atmosphere

224
00:07:19,189 --> 00:07:17,840
and that is caused by the condensation

225
00:07:24,550 --> 00:07:19,199
of

226
00:07:25,670 --> 00:07:24,560
is what actual cloud condensates are

227
00:07:27,830 --> 00:07:25,680
there water

228
00:07:29,990 --> 00:07:27,840
the blue lines stable throughout the

229
00:07:31,510 --> 00:07:30,000
atmosphere and then also graphite at the

230
00:07:33,110 --> 00:07:31,520
bottom of the atmosphere

231
00:07:35,589 --> 00:07:33,120
have that ammonium chloride and

232
00:07:38,230 --> 00:07:35,599
hydrosulfate if you want to investigate

233
00:07:39,830 --> 00:07:38,240
further uh temperatures at the same time

234
00:07:42,230 --> 00:07:39,840
of varying the surface

235
00:07:43,830 --> 00:07:42,240
temperatures that's uh going to be in

236
00:07:44,869 --> 00:07:43,840
the next spot but it's going to be a bit

237
00:07:47,270 --> 00:07:44,879
confusing so i'll just

238
00:07:48,510 --> 00:07:47,280

explain the access here so surface

239
00:07:51,830 --> 00:07:48,520
temperature

240
00:07:53,189 --> 00:07:51,840
300 to 1000 kelvin and then yeah each

241
00:07:56,869 --> 00:07:53,199
atmosphere is one column

242
00:07:59,350 --> 00:07:56,879
so a model with 400 kelvin starts here

243
00:07:59,909 --> 00:07:59,360
goes up goes up and it's just one column

244
00:08:02,309 --> 00:07:59,919
here

245
00:08:03,749 --> 00:08:02,319
if we plot now all of the condensates in

246
00:08:04,950 --> 00:08:03,759
here that are thermally stable and

247
00:08:07,990 --> 00:08:04,960
relatively abundant

248
00:08:09,110 --> 00:08:08,000
we get this result and that is actually

249
00:08:10,390 --> 00:08:09,120
really interesting because we

250
00:08:11,830 --> 00:08:10,400
already see here that we have a

251
00:08:12,950 --> 00:08:11,840
discrepancy between high temperature

252
00:08:13,589 --> 00:08:12,960
conditions and low temperature

253
00:08:16,790 --> 00:08:13,599
condensates

254
00:08:18,950 --> 00:08:16,800
chloride potassium chloride

255
00:08:20,869 --> 00:08:18,960
and iron sulfur whereas the low

256
00:08:23,909 --> 00:08:20,879
temperature condensates are water

257
00:08:25,430 --> 00:08:23,919
there's carbon the black lines and then

258
00:08:27,029 --> 00:08:25,440
as i mentioned earlier ammonium chloride

259
00:08:30,150 --> 00:08:27,039
potassium chloride but also

260
00:08:31,909 --> 00:08:30,160
sulfur s2 the orange one here forming

261
00:08:34,230 --> 00:08:31,919
some of the condensates

262
00:08:35,029 --> 00:08:34,240
if we compare this to the bulk silicate

263
00:08:37,269 --> 00:08:35,039

earth model

264
00:08:38,550 --> 00:08:37,279
we see that the overall image is roughly

265
00:08:39,750 --> 00:08:38,560
the same we have the high temperature

266
00:08:40,550 --> 00:08:39,760
concept and the low temperature

267
00:08:43,909 --> 00:08:40,560
condensates

268
00:08:45,430 --> 00:08:43,919
but there is graphite now breaching this

269
00:08:47,509 --> 00:08:45,440
gap of high and low temperature

270
00:08:49,670 --> 00:08:47,519
condensates and actually

271
00:08:51,750 --> 00:08:49,680
in our models we see that graphics the

272
00:08:53,670 --> 00:08:51,760
only concept that can do so

273
00:08:55,030 --> 00:08:53,680
so graphite is quite special and that

274
00:08:57,110 --> 00:08:55,040
needs to be investigated

275
00:08:58,389 --> 00:08:57,120
in the future of how we can form these

276
00:09:00,230 --> 00:08:58,399
graphite clouds

277
00:09:01,670 --> 00:09:00,240
some other points but also really

278
00:09:03,269 --> 00:09:01,680
interesting for the bulk silicate earth

279
00:09:05,110 --> 00:09:03,279
which does not have liquid water at the

280
00:09:07,269 --> 00:09:05,120
surface that's just as a reminder

281
00:09:08,550 --> 00:09:07,279
we see that we do have water clouds

282
00:09:10,310 --> 00:09:08,560
water ice clouds high up in the

283
00:09:13,350 --> 00:09:10,320
atmosphere

284
00:09:15,990 --> 00:09:13,360
and also when we just increase the

285
00:09:16,550 --> 00:09:16,000
the water abundance in that atmosphere a

286
00:09:19,590 --> 00:09:16,560
bit

287
00:09:21,590 --> 00:09:19,600
in the total element abundance but not

288
00:09:23,910 --> 00:09:21,600

allowing liquid water condensation yet

289
00:09:25,509 --> 00:09:23,920
we can drag down the water cloud base

290
00:09:27,110 --> 00:09:25,519
so that we can actually have water

291
00:09:30,470 --> 00:09:27,120
clouds at like roughly

292
00:09:32,790 --> 00:09:30,480
100 200 bar or 200 millibars

293
00:09:34,070 --> 00:09:32,800
whereas the surface is still quite still

294
00:09:37,269 --> 00:09:34,080
pretty dry

295
00:09:39,590 --> 00:09:37,279
and we actually only have water clouds

296
00:09:42,710 --> 00:09:39,600
touching the ground touching the surface

297
00:09:43,990 --> 00:09:42,720
when there is liquid water stable at the

298
00:09:47,110 --> 00:09:44,000
surface

299
00:09:48,870 --> 00:09:47,120
and that can also be seen in this plot

300
00:09:49,590 --> 00:09:48,880
when we don't have a constant surface

301
00:09:53,509 --> 00:09:49,600
pressure

302
00:09:56,710 --> 00:09:53,519
surface temperature in a way

303
00:09:58,070 --> 00:09:56,720
that we do have the exact same

304
00:09:59,910 --> 00:09:58,080
atmospheric structure for the high

305
00:10:00,550 --> 00:09:59,920
atmosphere so the higher parts of the

306
00:10:02,710 --> 00:10:00,560
atmosphere

307
00:10:04,870 --> 00:10:02,720
are the same in the pressure temperature

308
00:10:06,310 --> 00:10:04,880
profile for all of these models

309
00:10:07,910 --> 00:10:06,320
but they had just have different

310
00:10:09,910 --> 00:10:07,920
atmospheric depth

311
00:10:12,150 --> 00:10:09,920
and what we see here where i just shown

312
00:10:15,030 --> 00:10:12,160
you the um show you the

313
00:10:15,910 --> 00:10:15,040

what liquid water and water ice clouds

314
00:10:19,030 --> 00:10:15,920
we see

315
00:10:20,949 --> 00:10:19,040
that basically independent of the um

316
00:10:22,550 --> 00:10:20,959
of the actual surface pressure and

317
00:10:24,630 --> 00:10:22,560
surface temperature we have

318
00:10:26,310 --> 00:10:24,640
the ability to have liquid water clouds

319
00:10:27,190 --> 00:10:26,320
that is really interesting if one wants

320
00:10:29,750 --> 00:10:27,200
to think about

321
00:10:31,190 --> 00:10:29,760
some aerial biosphere some biology

322
00:10:34,630 --> 00:10:31,200
somewhere in clouds on a

323
00:10:35,590 --> 00:10:34,640
on a planet so that is already really

324
00:10:37,750 --> 00:10:35,600
interesting but the

325
00:10:38,710 --> 00:10:37,760
the second interesting part is when we

326
00:10:41,190 --> 00:10:38,720
take a look at

327
00:10:41,829 --> 00:10:41,200
all the other condensates that we have

328
00:10:46,790 --> 00:10:41,839
in the

329
00:10:47,350 --> 00:10:46,800
just want to mention the h2s cloud up

330
00:10:50,470 --> 00:10:47,360
here

331
00:10:52,949 --> 00:10:50,480
and that is only

332
00:10:53,670 --> 00:10:52,959
appearing for the high surface uh

333
00:10:55,190 --> 00:10:53,680
pressures

334
00:10:56,470 --> 00:10:55,200
where we have a high surface temperature

335
00:10:57,110 --> 00:10:56,480
with quite a lot of sulfur in the

336
00:10:58,550 --> 00:10:57,120
atmosphere

337
00:11:00,389 --> 00:10:58,560
and a lot of hydrogen in the aperture

338
00:11:01,190 --> 00:11:00,399

and then we can actually form the h2s

339
00:11:03,590 --> 00:11:01,200
elements

340
00:11:04,550 --> 00:11:03,600
and that can be used according to these

341
00:11:07,590 --> 00:11:04,560
models

342
00:11:09,190 --> 00:11:07,600
um as an in potential indicator for high

343
00:11:11,190 --> 00:11:09,200
surface pressures

344
00:11:12,630 --> 00:11:11,200
and with that i'd like to leave you with

345
00:11:14,389 --> 00:11:12,640
my conclusions that

346
00:11:16,069 --> 00:11:14,399
only the oversaturation of

347
00:11:18,069 --> 00:11:16,079
phyllosilicates can result

348
00:11:20,389 --> 00:11:18,079
in stable water condensing and chemical

349
00:11:21,750 --> 00:11:20,399
equilibrium at the surface

350
00:11:23,430 --> 00:11:21,760
but independent of whether or not

351
00:11:25,190 --> 00:11:23,440
there's liquid water at the surface

352
00:11:27,350 --> 00:11:25,200
we can have water clouds in the

353
00:11:30,630 --> 00:11:27,360
atmosphere and overall

354
00:11:32,550 --> 00:11:30,640
we want to use this model to

355
00:11:34,150 --> 00:11:32,560
get an insight of what kind of crust

356
00:11:37,350 --> 00:11:34,160
induces what kind of clouds

357
00:11:40,310 --> 00:11:37,360
and then to basically trace back we see

358
00:11:41,509 --> 00:11:40,320
cloud a and then say that could be this

359
00:11:43,190 --> 00:11:41,519
kind of cloud

360
00:11:45,110 --> 00:11:43,200
these kind of crosstabs thank you very

361
00:11:47,030 --> 00:11:45,120
much for listening