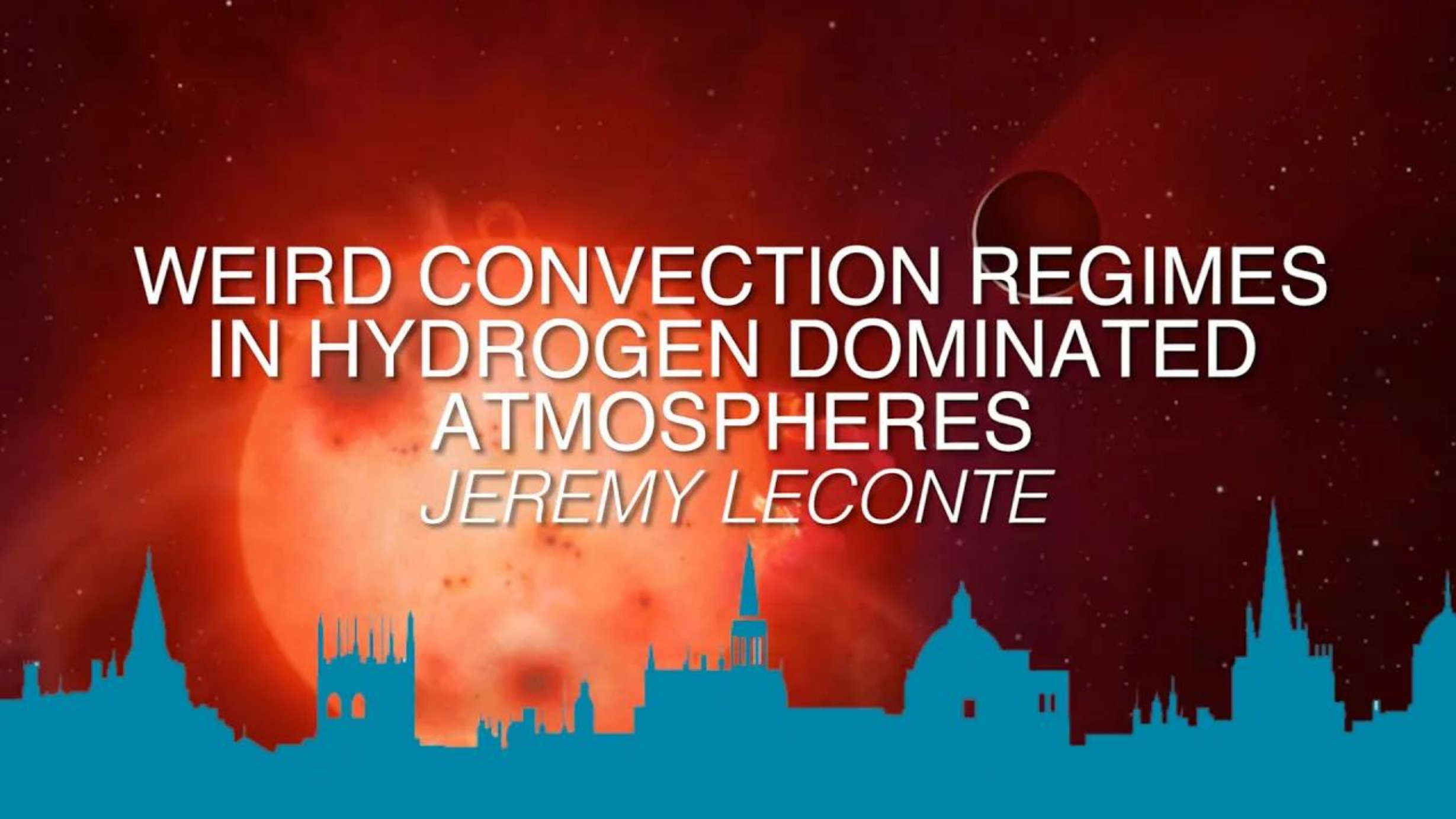
WEIRD CONVECTION REGIMES
IN HYDROGEN DOMINATED
ATMOSPHERES
JEREMY LECONTE

1
00:00:01,350 --> 00:00:06,490
[Music]

2
00:00:12,680 --> 00:00:09,919
if you want to apply connection to other

3
00:00:15,560 --> 00:00:12,690
planets you need to think of what could

4
00:00:17,390 --> 00:00:15,570
happen if you change the gas involved so

5
00:00:20,000 --> 00:00:17,400
of course as we said we could change the

6
00:00:22,130 --> 00:00:20,010
common table gas but we can also change

7
00:00:26,109 --> 00:00:22,140
for example what is the background gas

8
00:00:29,390 --> 00:00:26,119
hydrogen but then you really don't see

9
00:00:31,550 --> 00:00:29,400
what could happen because basically you

10
00:00:34,389 --> 00:00:31,560
have a gas hydrogen or nitrogen it's

11
00:00:38,420 --> 00:00:34,399
basically the same thing it has the same

12
00:00:42,260 --> 00:00:38,430
it has the same structure it's not

13
00:00:44,330 --> 00:00:42,270

particularly relatively active so what

14
00:00:46,729 --> 00:00:44,340
does what does happen but first what the

15
00:00:48,799 --> 00:00:46,739
why do you care what could happen if you

16
00:00:51,410 --> 00:00:48,809
have conviction in a hydrogen dominated

17
00:00:54,049 --> 00:00:51,420
measure well you can care because as we

18
00:00:58,520 --> 00:00:54,059
saw yesterday it does happen and we do

19
00:01:02,060 --> 00:00:58,530
see it so for example you have the you

20
00:01:04,340 --> 00:01:02,070
have here a cyclone it's an it's on

21
00:01:06,289 --> 00:01:04,350
Jupiter and as we were talking about

22
00:01:08,000 --> 00:01:06,299
convection happening on very different

23
00:01:10,580 --> 00:01:08,010
scales actually here the scale of the

24
00:01:13,250 --> 00:01:10,590
spectrum is the earth okay you could fit

25
00:01:15,530 --> 00:01:13,260
near Earth in there and basically you

26
00:01:17,450 --> 00:01:15,540
see for example here clouds they are not

27
00:01:18,859 --> 00:01:17,460
water cloud the ammonia cloud and you

28
00:01:20,749 --> 00:01:18,869
see that they are actually hi hug

29
00:01:24,190 --> 00:01:20,759
because here or there you can see the

30
00:01:29,270 --> 00:01:24,200
shadow that the cast over the the lower

31
00:01:31,870 --> 00:01:29,280
level gas or clouds so you do have

32
00:01:34,190 --> 00:01:31,880
convection and and you do have very

33
00:01:37,670 --> 00:01:34,200
extreme convection when you look for

34
00:01:40,609 --> 00:01:37,680
example at this which is a well-known

35
00:01:43,249 --> 00:01:40,619
photograph of the the Saturn great white

36
00:01:46,460 --> 00:01:43,259
white storm where you actually it's a

37
00:01:49,340 --> 00:01:46,470
couple weeks a month after it began and

38
00:01:51,740 --> 00:01:49,350

then you already see this big storm you

39
00:01:53,929 --> 00:01:51,750
have the wind shear that creates trail

40
00:01:56,929 --> 00:01:53,939
and then the storm has time to actually

41
00:01:59,719 --> 00:01:56,939
circle the trail had time to shape of

42
00:02:03,859 --> 00:01:59,729
the planet and so again the question is

43
00:02:06,080 --> 00:02:03,869
yes but how does how is this couldn't be

44
00:02:09,410 --> 00:02:06,090
different from what we just heard for

45
00:02:13,130 --> 00:02:09,420
earth convection and arid it if you have

46
00:02:15,170 --> 00:02:13,140
earth or or your generic moist planet

47
00:02:16,640 --> 00:02:15,180
that goes as we heard you have your

48
00:02:19,280 --> 00:02:16,650
temperature profile that is going

49
00:02:21,680 --> 00:02:19,290
basically on the moist adiabat where you

50
00:02:25,580 --> 00:02:21,690
have your moist troposphere and you have

51
00:02:28,309 --> 00:02:25,590
your humidity here EQ is what I call the

52
00:02:31,310 --> 00:02:28,319
the specialty community so the amount of

53
00:02:33,199 --> 00:02:31,320
water vapor pair amount of dry air and

54
00:02:36,430 --> 00:02:33,209
medic it goes down because you have to

55
00:02:40,370 --> 00:02:36,440
follow them a thermodynamic flow and so

56
00:02:42,699 --> 00:02:40,380
as it's warmer down there

57
00:02:46,130 --> 00:02:42,709
you have more water vapor and and it's

58
00:02:50,080 --> 00:02:46,140
colder there you have a drier dryer air

59
00:02:52,910 --> 00:02:50,090
and then of course here as we heard

60
00:02:55,310 --> 00:02:52,920
convection is mostly due to thermal

61
00:02:56,570 --> 00:02:55,320
gradient that is caused by radiation so

62
00:02:59,540 --> 00:02:56,580
basically the fact that it's hotter

63
00:03:03,449 --> 00:02:59,550

there but it's also helped by as we

64
00:03:10,530 --> 00:03:03,459
offer also add latent heat book

65
00:03:13,289 --> 00:03:10,540
or about that so it's held by latent

66
00:03:15,149 --> 00:03:13,299
heat but it's also held button by

67
00:03:16,920 --> 00:03:15,159
another process we didn't hear about

68
00:03:18,539 --> 00:03:16,930
which is the fact that you have a

69
00:03:20,940 --> 00:03:18,549
difference in molecular weight so what

70
00:03:24,119 --> 00:03:20,950
is this basically in Earth your

71
00:03:26,429 --> 00:03:24,129
background gas is nitrogen and and then

72
00:03:29,879 --> 00:03:26,439
the the the mean molecular weights the

73
00:03:32,220 --> 00:03:29,889
weight of a molecule of nitrogen is 28

74
00:03:35,429 --> 00:03:32,230
but then the the minimal ocular weight

75
00:03:37,379 --> 00:03:35,439
of water is 18 you have 18 new clients

76
00:03:39,149 --> 00:03:37,389
in in the water molecule and so

77
00:03:41,819 --> 00:03:39,159
basically what it does is that here

78
00:03:43,740 --> 00:03:41,829
because you have more water and that

79
00:03:46,409 --> 00:03:43,750
water is a bit lighter than nitrogen

80
00:03:48,959 --> 00:03:46,419
it's a little bit less dense here then

81
00:03:51,149 --> 00:03:48,969
here and so basically you have another

82
00:03:53,280 --> 00:03:51,159
process helping you because when you

83
00:03:55,289 --> 00:03:53,290
want convection you want hot stuff but

84
00:03:58,229 --> 00:03:55,299
why do you want you we won't let them

85
00:04:00,869 --> 00:03:58,239
stuff so here because you have water you

86
00:04:05,849 --> 00:04:00,879
have blend temps less dense air moist

87
00:04:08,849 --> 00:04:05,859
air that will be helped to get lost so

88
00:04:11,399 --> 00:04:08,859

that's a variant see effect so how does

89
00:04:14,960 --> 00:04:11,409
it change when you go to a jump and for

90
00:04:17,550 --> 00:04:14,970
ample so the the most important one one

91
00:04:19,409 --> 00:04:17,560
change is basically that you don't have

92
00:04:21,539 --> 00:04:19,419
a surface but that doesn't change too

93
00:04:24,540 --> 00:04:21,549
much so what basically happens is that

94
00:04:27,899 --> 00:04:24,550
in your atmosphere in your planet you

95
00:04:31,770 --> 00:04:27,909
have some deep abundance of your oxygen

96
00:04:33,870 --> 00:04:31,780
or in so basically of your water and so

97
00:04:36,330 --> 00:04:33,880
basically what happens is that you still

98
00:04:40,230 --> 00:04:36,340
at your moist rodebush here and you have

99
00:04:41,999 --> 00:04:40,240
your water vapor to saturation that is

100
00:04:44,670 --> 00:04:42,009
trying to follow the determined

101
00:04:49,140 --> 00:04:44,680
dynamical law and at some point it hits

102
00:04:51,029 --> 00:04:49,150
the the value of your deep interior and

103
00:04:53,100 --> 00:04:51,039
then you cannot you can't have more

104
00:04:57,149 --> 00:04:53,110
water than that and so basically here

105
00:04:59,969 --> 00:04:57,159
water stops to condense so you just have

106
00:05:03,210 --> 00:04:59,979
a constant or multi constant amount of

107
00:05:06,089 --> 00:05:03,220
water then you have a dry troposphere so

108
00:05:09,719 --> 00:05:06,099
now the lapse rate is not a most lapse

109
00:05:11,430 --> 00:05:09,729
rate but a dry lapse rate and here that

110
00:05:13,469 --> 00:05:11,440
pretty easy because that's where you

111
00:05:15,709 --> 00:05:13,479
would expect clouds to be because you

112
00:05:17,320 --> 00:05:15,719
can't have clouds down below the clouds

113
00:05:20,110 --> 00:05:17,330

particles the

114
00:05:22,149 --> 00:05:20,120
not easy to laugh too much too much

115
00:05:24,670 --> 00:05:22,159
higher than this but basically the deck

116
00:05:27,279 --> 00:05:24,680
you you should have a deck of clouds

117
00:05:29,230 --> 00:05:27,289
pretty much at this level of transition

118
00:05:32,200 --> 00:05:29,240
between the dry and the moisture of the

119
00:05:34,659 --> 00:05:32,210
sphere but what is really really

120
00:05:36,820 --> 00:05:34,669
different is that whereas in Earth we

121
00:05:39,159 --> 00:05:36,830
had a profile profile of mini molecular

122
00:05:41,830 --> 00:05:39,169
weight like that now we don't have em

123
00:05:44,980 --> 00:05:41,840
too as a background gas we have we have

124
00:05:47,920 --> 00:05:44,990
H 2 and H 2 as a minimal ocular weight

125
00:05:51,909 --> 00:05:47,930
of 2 it's tiny it's not a fraction

126
00:05:54,730 --> 00:05:51,919
higher than water it's 10 times lower

127
00:05:57,999 --> 00:05:54,740
than water so actually you can have a

128
00:06:00,520 --> 00:05:58,009
huge huge gradient of min molecular

129
00:06:03,189 --> 00:06:00,530
weight but as you so the minimal acrylic

130
00:06:06,520 --> 00:06:03,199
gradient is not the same way as before

131
00:06:09,850 --> 00:06:06,530
here you have lighter water for gas on

132
00:06:11,559 --> 00:06:09,860
top of heavier water rich gas so you

133
00:06:14,379 --> 00:06:11,569
have a problem because you have again a

134
00:06:17,140 --> 00:06:14,389
battle or competition because you have a

135
00:06:21,010 --> 00:06:17,150
competition between your radiation that

136
00:06:24,700 --> 00:06:21,020
wants actually you to come back and this

137
00:06:27,279 --> 00:06:24,710
process that tries not that tries to

138
00:06:32,110 --> 00:06:27,289

suppress that convection so how do you

139
00:06:33,869 --> 00:06:32,120
how can we actually quantify that so

140
00:06:37,990 --> 00:06:33,879
basically you can come back to your

141
00:06:40,719 --> 00:06:38,000
convection 1 1 and and try to understand

142
00:06:43,659 --> 00:06:40,729
first what would be the convection

143
00:06:46,089 --> 00:06:43,669
pattern in a dry atmosphere I'm actually

144
00:06:48,309 --> 00:06:46,099
basically this is this you have your

145
00:06:50,920 --> 00:06:48,319
density in the atmosphere as a function

146
00:06:53,529 --> 00:06:50,930
of height and here the dotted line is

147
00:06:55,779 --> 00:06:53,539
the the density profile that you would

148
00:07:00,369 --> 00:06:55,789
have in your atmosphere with some

149
00:07:02,920 --> 00:07:00,379
thermal gradient nabrit and then you

150
00:07:06,519 --> 00:07:02,930
have your adiabatic gradient this is the

151
00:07:08,769 --> 00:07:06,529
gradient of density that a particle

152
00:07:10,839 --> 00:07:08,779
would follow if it were moved in the

153
00:07:13,499 --> 00:07:10,849
atmosphere adiabatically so without any

154
00:07:17,050 --> 00:07:13,509
exchange of heat so let's try to have a

155
00:07:20,619 --> 00:07:17,060
particle here so you take a given

156
00:07:22,329 --> 00:07:20,629
particle they're completely you move it

157
00:07:25,329 --> 00:07:22,339
for some reason you have a disturbance

158
00:07:27,399 --> 00:07:25,339
that moves it up and here it moves on

159
00:07:30,350 --> 00:07:27,409
the adiabatic profile and then here

160
00:07:32,420 --> 00:07:30,360
because it's denser than its environment

161
00:07:35,600 --> 00:07:32,430
if we'll be pushed back by buoyancy and

162
00:07:38,559 --> 00:07:35,610
you have a stable atmosphere now what

163
00:07:44,029 --> 00:07:38,569

happens if you have the the the reverse

164
00:07:48,339 --> 00:07:44,039
the reversed conditions here now your

165
00:07:53,679 --> 00:07:48,349
gradient in the atmosphere is bigger and

166
00:07:59,029 --> 00:07:53,689
if you have your parcel of air going up

167
00:08:03,140 --> 00:07:59,039
then you're less dense and you you your

168
00:08:05,540 --> 00:08:03,150
particle is a boost up again so little

169
00:08:07,760 --> 00:08:05,550
disturbance is further amplified and

170
00:08:09,649 --> 00:08:07,770
that's what we call convection and that

171
00:08:12,770 --> 00:08:09,659
means that your convection happens

172
00:08:14,450 --> 00:08:12,780
basically when your gradient is bigger

173
00:08:17,119 --> 00:08:14,460
than the adiabatic gradient and that's

174
00:08:21,290 --> 00:08:17,129
what we call the well known for chill

175
00:08:23,180 --> 00:08:21,300
criterion now as I said we want to

176
00:08:25,939 --> 00:08:23,190
include min molecular weight we want to

177
00:08:30,740 --> 00:08:25,949
add another another parameter so we have

178
00:08:33,889 --> 00:08:30,750
to go bit further and then again we have

179
00:08:38,930 --> 00:08:33,899
our thermal gradient but what can happen

180
00:08:42,139 --> 00:08:38,940
is that you can add a gradient update

181
00:08:45,259 --> 00:08:42,149
for calm ego so you have your

182
00:08:47,210 --> 00:08:45,269
particulate that went up now the thing

183
00:08:48,680 --> 00:08:47,220
is in your environment you don't only

184
00:08:52,189 --> 00:08:48,690
have a thermal gradient you also have a

185
00:08:54,949 --> 00:08:52,199
gradient of the heavy element okay so as

186
00:08:58,610 --> 00:08:54,959
you see here you would imagine that your

187
00:09:00,170 --> 00:08:58,620
particle is for example lighter than its

188
00:09:02,569 --> 00:09:00,180

environment but as you see the color is

189
00:09:05,120 --> 00:09:02,579
not the same so here this particle still

190
00:09:08,780 --> 00:09:05,130
has the same composition as here and

191
00:09:12,710 --> 00:09:08,790
basically it is a shown well wet by the

192
00:09:15,139 --> 00:09:12,720
by this term here the gradient of mean

193
00:09:17,720 --> 00:09:15,149
molecular weight in the environment can

194
00:09:19,430 --> 00:09:17,730
offset the effect of temperature and

195
00:09:22,310 --> 00:09:19,440
basically you see that it's a negative

196
00:09:26,269 --> 00:09:22,320
sign so basically if you have more Eva

197
00:09:28,670 --> 00:09:26,279
stuff below it will stabilize you at

198
00:09:31,069 --> 00:09:28,680
magenta so that's what can happen here

199
00:09:36,500 --> 00:09:31,079
where basically your density gradient

200
00:09:39,019 --> 00:09:36,510
will be a little bit lower and here is a

201
00:09:41,860 --> 00:09:39,029
new criterion to know whether this is

202
00:09:43,960 --> 00:09:41,870
going to be stable or not and this is

203
00:09:46,329 --> 00:09:43,970
inverse this is a lot of

204
00:09:49,449 --> 00:09:46,339
Italian and this is basically involving

205
00:09:51,490 --> 00:09:49,459
your thermal gradient you mean molecular

206
00:09:53,790 --> 00:09:51,500
weight gradient in the in the

207
00:09:57,009 --> 00:09:53,800
environment and your adiabatic region

208
00:10:00,519 --> 00:09:57,019
but of course as we saw the problem is

209
00:10:02,290 --> 00:10:00,529
here this is only if you have no

210
00:10:04,569 --> 00:10:02,300
compositional change in your bubble and

211
00:10:06,910 --> 00:10:04,579
because basically you have let's say

212
00:10:09,249 --> 00:10:06,920
dust or something that can be really

213
00:10:13,240 --> 00:10:09,259

affected without changing but what

214
00:10:18,639 --> 00:10:13,250
happens for implementation because here

215
00:10:20,139 --> 00:10:18,649
you see that as you your environment is

216
00:10:22,809 --> 00:10:20,149
going to have a gradient of temperature

217
00:10:24,639 --> 00:10:22,819
and Composition but then in your bubble

218
00:10:26,800 --> 00:10:24,649
as it evolves because there is going to

219
00:10:29,679 --> 00:10:26,810
be condensation so there is going to be

220
00:10:32,230 --> 00:10:29,689
also a change in temperature and in

221
00:10:34,449 --> 00:10:32,240
composition and you have to put terminal

222
00:10:36,790 --> 00:10:34,459
in a mix in there and so I guess you can

223
00:10:42,309 --> 00:10:36,800
now understand that you have to add this

224
00:10:44,679 --> 00:10:42,319
motor and that's where basically you can

225
00:10:47,980 --> 00:10:44,689
feel that it's it's gonna it's gonna get

226
00:10:52,210 --> 00:10:47,990
pretty machine can't you because you see

227
00:10:53,949 --> 00:10:52,220
the big equations coming so if you can't

228
00:10:56,259 --> 00:10:53,959
either because you're very bright

229
00:10:58,269 --> 00:10:56,269
Oh bear smell because actually there is

230
00:11:01,660 --> 00:10:58,279
a very very interesting thing happening

231
00:11:04,720 --> 00:11:01,670
if it's magic of thermodynamics because

232
00:11:07,629 --> 00:11:04,730
basically if you're in a saturated

233
00:11:09,280 --> 00:11:07,639
atmosphere it means that your gradients

234
00:11:11,769 --> 00:11:09,290
of mini molecular weight or your

235
00:11:14,619 --> 00:11:11,779
gradient of water vapor is you will is

236
00:11:16,780 --> 00:11:14,629
going to be linked to the moment just

237
00:11:20,350 --> 00:11:16,790
because of condensation condensation

238
00:11:22,480 --> 00:11:20,360

loss so these two cannot evolve

239
00:11:25,929 --> 00:11:22,490
separately and these two are the same

240
00:11:28,389 --> 00:11:25,939
this one will the condensation so the

241
00:11:30,400 --> 00:11:28,399
amount the saturation will depend on

242
00:11:32,619 --> 00:11:30,410
temperature as well and so basically

243
00:11:34,720 --> 00:11:32,629
what happens is that all this is

244
00:11:36,549 --> 00:11:34,730
proportional to the thermal gradient all

245
00:11:38,590 --> 00:11:36,559
this is proportional to thermal gradient

246
00:11:42,340 --> 00:11:38,600
and the thermal gradients disappear and

247
00:11:46,439 --> 00:11:42,350
you have a magic new criterion where

248
00:11:50,619 --> 00:11:46,449
basically you just know that convection

249
00:11:53,650 --> 00:11:50,629
is shut down whenever your amount of

250
00:11:56,429 --> 00:11:53,660
water vapor in the atmosphere is bigger

251
00:11:57,490 --> 00:11:56,439
than some magic critical abundance and

252
00:12:00,910 --> 00:11:57,500
that

253
00:12:02,800 --> 00:12:00,920
depends only on the difference of the

254
00:12:06,000 --> 00:12:02,810
mid molecular weight between your vapor

255
00:12:09,580 --> 00:12:06,010
or your your commencing species and your

256
00:12:11,800 --> 00:12:09,590
non Comanche species and about the

257
00:12:13,570 --> 00:12:11,810
channel thermo dynamical properties of

258
00:12:16,900 --> 00:12:13,580
your condensation so basically the

259
00:12:18,910 --> 00:12:16,910
latent heat so how does it go what does

260
00:12:23,860 --> 00:12:18,920
it do to your atmosphere so basically

261
00:12:26,350 --> 00:12:23,870
what happens is that you have here your

262
00:12:29,920 --> 00:12:26,360
moisture pause fear dry they're bad if

263
00:12:32,700 --> 00:12:29,930

you have an internal amount of water

264
00:12:35,620 --> 00:12:32,710
vapor that is below this critical value

265
00:12:37,600 --> 00:12:35,630
you'll find but when it's above this

266
00:12:40,150 --> 00:12:37,610
critical value basically what happens

267
00:12:43,360 --> 00:12:40,160
you start here to suppress convection

268
00:12:45,760 --> 00:12:43,370
and then you only have radiation to get

269
00:12:47,710 --> 00:12:45,770
you energy out so you get a relative

270
00:12:50,980 --> 00:12:47,720
layer and so you have a very big

271
00:12:54,880 --> 00:12:50,990
increase in temperature somehow you heat

272
00:12:58,510 --> 00:12:54,890
again the value of your internal amount

273
00:13:01,240 --> 00:12:58,520
of water or all those species and then

274
00:13:03,490 --> 00:13:01,250
you fall back on the dry adiabat the

275
00:13:05,800 --> 00:13:03,500
question is what species are interesting

276
00:13:07,630 --> 00:13:05,810
to do this what I did is just compute

277
00:13:10,210 --> 00:13:07,640
this for different species and you can

278
00:13:12,400 --> 00:13:10,220
do it for for all the others but that

279
00:13:14,320 --> 00:13:12,410
doesn't tell you the whole story we also

280
00:13:17,920 --> 00:13:14,330
have to look for what are the species

281
00:13:21,910 --> 00:13:17,930
that are really abundant in the universe

282
00:13:24,220 --> 00:13:21,920
and so you just put in the for example

283
00:13:25,750 --> 00:13:24,230
the solar abundance and you see here the

284
00:13:29,950 --> 00:13:25,760
enrichment that an atmosphere should

285
00:13:31,950 --> 00:13:29,960
need to have to actually show this kind

286
00:13:34,750 --> 00:13:31,960
of behavior and you see that the most

287
00:13:36,850 --> 00:13:34,760
the most promising is of course is water

288
00:13:40,090 --> 00:13:36,860

you only need a ten times the solar

289
00:13:45,040 --> 00:13:40,100
enrichment and then ch4 and then nh3 and

290
00:13:47,800 --> 00:13:45,050
maybe iron but so so that's that's

291
00:13:50,290 --> 00:13:47,810
really interesting so what does it do if

292
00:13:52,930 --> 00:13:50,300
you look at for example Jupiter here is

293
00:13:54,670 --> 00:13:52,940
a profile so you just add the observed

294
00:13:58,210 --> 00:13:54,680
value at one bar for the temperature and

295
00:14:00,940 --> 00:13:58,220
here is BIOS profile as you increase the

296
00:14:04,329 --> 00:14:00,950
amount of water vapor or the oxygen

297
00:14:05,829 --> 00:14:04,339
amount if you will in in Jupiter and

298
00:14:08,470 --> 00:14:05,839
what you see that the internal temp

299
00:14:10,170 --> 00:14:08,480
attraction decrease with the amount of

300
00:14:13,350 --> 00:14:10,180
water vapor in Jupiter but

301
00:14:15,480 --> 00:14:13,360
if you account for this inhibition from

302
00:14:17,820 --> 00:14:15,490
infection basically that completely

303
00:14:19,620 --> 00:14:17,830
change the the type of profiles you

304
00:14:21,930 --> 00:14:19,630
would have and that changed the internal

305
00:14:25,110 --> 00:14:21,940
temperature so the thing is that I think

306
00:14:27,410 --> 00:14:25,120
it would be it could be maybe detectable

307
00:14:29,970 --> 00:14:27,420
with Juno although there may be some

308
00:14:31,949 --> 00:14:29,980
program of degeneracy is within the

309
00:14:35,070 --> 00:14:31,959
measurement but the planet that it

310
00:14:36,840 --> 00:14:35,080
probably requires too high amount of

311
00:14:40,199 --> 00:14:36,850
water it's actually interesting because

312
00:14:42,810 --> 00:14:40,209
it does explain the properties of Saturn

313
00:14:45,600 --> 00:14:42,820

and so if you want to put that in the

314
00:14:47,670 --> 00:14:45,610
occupied context of course you can think

315
00:14:50,880 --> 00:14:47,680
of when every node for example in

316
00:14:53,280 --> 00:14:50,890
hydrogen acid but now I want to quickly

317
00:14:55,500 --> 00:14:53,290
move to another area which is well why

318
00:14:57,389 --> 00:14:55,510
does that matter to brown dwarfs so of

319
00:14:59,639 --> 00:14:57,399
course Brown rods or maybe not that

320
00:15:03,139 --> 00:14:59,649
metal which but where does compositional

321
00:15:05,970 --> 00:15:03,149
conviction could play so there is this

322
00:15:08,220 --> 00:15:05,980
long-standing problem that when you go

323
00:15:10,590 --> 00:15:08,230
to the see the brown drop sequence in

324
00:15:12,810 --> 00:15:10,600
the color of magnitude diagram you have

325
00:15:16,140 --> 00:15:12,820
this wiggle here that we call the MLC

326
00:15:17,910 --> 00:15:16,150
transition and the price that you need

327
00:15:21,930 --> 00:15:17,920
to have something to actually explain

328
00:15:24,720 --> 00:15:21,940
this and to explain this basically you

329
00:15:26,190 --> 00:15:24,730
need to read on all these L words and to

330
00:15:28,050 --> 00:15:26,200
read on a brand watch you need to

331
00:15:33,870 --> 00:15:28,060
decrease the brightness temperature the

332
00:15:35,010 --> 00:15:33,880
brightness difference between you are to

333
00:15:36,980 --> 00:15:35,020
decrease the brightness temperature in

334
00:15:40,430 --> 00:15:36,990
the near-infrared is that you have

335
00:15:44,550 --> 00:15:40,440
mostly one way which is to put something

336
00:15:47,250 --> 00:15:44,560
higher like clouds the address issue

337
00:15:49,500 --> 00:15:47,260
well that will emit higher from colder

338
00:15:51,360 --> 00:15:49,510

regions and then you can expand that or

339
00:15:53,790 --> 00:15:51,370
the problem is that there is some

340
00:15:55,829 --> 00:15:53,800
characterization going on so there's

341
00:15:59,340 --> 00:15:55,839
been another ideas in the literature

342
00:16:00,750 --> 00:15:59,350
which is to basically cool down the deep

343
00:16:03,569 --> 00:16:00,760
atmosphere and that does the thing

344
00:16:05,670 --> 00:16:03,579
without sharks but of course I just want

345
00:16:09,660 --> 00:16:05,680
to remind you that even though this

346
00:16:11,280 --> 00:16:09,670
could work I don't exactly see how you

347
00:16:13,470 --> 00:16:11,290
could have ground was without that

348
00:16:15,690 --> 00:16:13,480
because you are financing things so they

349
00:16:19,610 --> 00:16:15,700
need to connect at some point but anyway

350
00:16:22,140 --> 00:16:19,620
let's try to work it with with this and

351
00:16:22,770 --> 00:16:22,150
so there was this really interesting by

352
00:16:24,630 --> 00:16:22,780
I

353
00:16:27,120 --> 00:16:24,640
your Pascal from running is going to

354
00:16:29,280 --> 00:16:27,130
talk just after which is the fact that

355
00:16:31,890 --> 00:16:29,290
this transition actually occurs at a

356
00:16:33,960 --> 00:16:31,900
chemical transition between Co dominated

357
00:16:35,640 --> 00:16:33,970
and huge for dominated atmosphere and

358
00:16:37,500 --> 00:16:35,650
that's interesting because if you look

359
00:16:38,700 --> 00:16:37,510
at this huge food immunity that with you

360
00:16:41,850 --> 00:16:38,710
you basically have an atmosphere like

361
00:16:44,790 --> 00:16:41,860
this this is a little bit colder you

362
00:16:46,920 --> 00:16:44,800
have ch4 which gas all the way and so

363
00:16:49,290 --> 00:16:46,930

you mean molecular weight doesn't do

364
00:16:52,470 --> 00:16:49,300
anything and it's stable if you go to a

365
00:16:55,110 --> 00:16:52,480
little bit hotter things then you have

366
00:16:57,630 --> 00:16:55,120
Co gas down there and teach for which

367
00:17:01,170 --> 00:16:57,640
gas up there the thing is that the siege

368
00:17:04,230 --> 00:17:01,180
for which gas is actually a bit heavier

369
00:17:06,540 --> 00:17:04,240
than the still gas and so basically this

370
00:17:08,670 --> 00:17:06,550
is potentially unstable and so that

371
00:17:10,290 --> 00:17:08,680
would lead to mixing and that's what I

372
00:17:15,150 --> 00:17:10,300
really loved about this idea because

373
00:17:17,670 --> 00:17:15,160
it's really you think this and say well

374
00:17:20,120 --> 00:17:17,680
instability should really offer what I

375
00:17:23,579 --> 00:17:20,130
didn't so much like about this idea that

376
00:17:27,929 --> 00:17:23,589
the way they implemented this mixing was

377
00:17:30,540 --> 00:17:27,939
mostly making it acts like diffusion and

378
00:17:33,330 --> 00:17:30,550
that makes sense so basically what they

379
00:17:36,000 --> 00:17:33,340
did is saying okay we have a turbulent

380
00:17:37,890 --> 00:17:36,010
flux lag that we write like this so if

381
00:17:40,920 --> 00:17:37,900
we have some mixing process we increase

382
00:17:43,140 --> 00:17:40,930
the disk AGG so to have the same flux

383
00:17:45,600 --> 00:17:43,150
will just decrease the thermal gradient

384
00:17:49,830 --> 00:17:45,610
and basically you go from a stable

385
00:17:52,800 --> 00:17:49,840
atmosphere that is like this to more of

386
00:17:54,450 --> 00:17:52,810
a family atmosphere and it kind of makes

387
00:17:56,250 --> 00:17:54,460
sense as well because intuitively you

388
00:17:58,380 --> 00:17:56,260

would think okay we have we have mixing

389
00:17:59,790 --> 00:17:58,390
so basically what does mixing do as we

390
00:18:02,100 --> 00:17:59,800
heard for for the earth

391
00:18:04,980 --> 00:18:02,110
you take energy there and you put it

392
00:18:07,170 --> 00:18:04,990
down so you kind of always put energy

393
00:18:09,600 --> 00:18:07,180
report so you you would put two two more

394
00:18:11,850 --> 00:18:09,610
I for summer conditions the problem is

395
00:18:15,360 --> 00:18:11,860
that it's actually what happens when you

396
00:18:17,520 --> 00:18:15,370
have a convective the unstable regions

397
00:18:19,920 --> 00:18:17,530
but here you're forcing mixing in a

398
00:18:22,670 --> 00:18:19,930
convective least stable region and so

399
00:18:25,970 --> 00:18:22,680
actually what does happen is that mixing

400
00:18:29,100 --> 00:18:25,980
mixes enthalpy it doesn't mix

401
00:18:30,360 --> 00:18:29,110
temperature so basically it's not the

402
00:18:32,870 --> 00:18:30,370
turbulent flux is not written like that

403
00:18:36,010 --> 00:18:32,880
it's written like that as a flux of

404
00:18:39,280 --> 00:18:36,020
turbulence of entropy and

405
00:18:41,290 --> 00:18:39,290
basically when you remember when you up

406
00:18:44,320 --> 00:18:41,300
meant when you increase the turbulence

407
00:18:46,270 --> 00:18:44,330
by any process what you do is not going

408
00:18:49,540 --> 00:18:46,280
to more and more isothermal you go to

409
00:18:52,660 --> 00:18:49,550
other more adiabatic conditions and and

410
00:18:55,500 --> 00:18:52,670
even though it's continuity that you can

411
00:18:57,940 --> 00:18:55,510
show from the Ida dynamical literature

412
00:19:00,490 --> 00:18:57,950
theorems that show that actually in a

413
00:19:04,000 --> 00:19:00,500

stable a to say to mix you actually go

414
00:19:07,630 --> 00:19:04,010
toward at about you actually bury it so

415
00:19:11,049 --> 00:19:07,640
you have a negative flux of heat and

416
00:19:13,900 --> 00:19:11,059
basically instead of of going to more

417
00:19:17,169 --> 00:19:13,910
algebra isothermal conditions you have

418
00:19:19,180 --> 00:19:17,179
more adiabatic conditions and so instead

419
00:19:21,490 --> 00:19:19,190
of decreasing the temperature of the

420
00:19:23,980 --> 00:19:21,500
Lord Michelle this actually increase the

421
00:19:27,669 --> 00:19:23,990
temperature the higher the lower

422
00:19:29,470 --> 00:19:27,679
atmosphere so like that I don't think

423
00:19:35,650 --> 00:19:29,480
this process can really really work

424
00:19:38,110 --> 00:19:35,660
however I know that Pascal after a lot

425
00:19:42,390 --> 00:19:38,120
of dishes well it worked a lot and he

426
00:19:46,090 --> 00:19:42,400
actually found the place I think to

427
00:19:48,400 --> 00:19:46,100
actually make it work if you convection

428
00:19:50,860 --> 00:19:48,410
now is not added at the batting as I

429
00:19:52,210 --> 00:19:50,870
said but if there is some source of

430
00:19:55,360 --> 00:19:52,220
energy and in this case I think

431
00:19:58,299 --> 00:19:55,370
radiation pouring this tradition I think

432
00:20:00,400 --> 00:19:58,309
that I or at least I hope this is a good

433
00:20:15,340 --> 00:20:00,410
transition to the next door and with

434
00:20:20,060 --> 00:20:18,230
hi Hugo and at University of Exeter

435
00:20:23,150 --> 00:20:20,070
have you thought about the effect of

436
00:20:24,860 --> 00:20:23,160
convective entrainment when you move to

437
00:20:26,480 --> 00:20:24,870
jump on plan atmospheres in other words

438
00:20:28,820 --> 00:20:26,490

where you have so you have these plumes

439
00:20:32,210 --> 00:20:28,830
of rising fluid and on earth what

440
00:20:33,980 --> 00:20:32,220
happens if those enter a dry region and

441
00:20:36,140 --> 00:20:33,990
it pulls in dry air that tends to

442
00:20:38,210 --> 00:20:36,150
downtown the convection but if you're

443
00:20:44,290 --> 00:20:38,220
putting in a lighter fluid like hydrogen

444
00:20:50,360 --> 00:20:47,630
tell you where we're trying in it's

445
00:20:52,430 --> 00:20:50,370
trying to to actually resolving Falls of

446
00:20:54,290 --> 00:20:52,440
this kind of thing because it's really

447
00:20:55,880 --> 00:20:54,300
where you can see this kind of effect

448
00:21:03,500 --> 00:20:55,890
because you cannot resolve the

449
00:21:09,230 --> 00:21:05,560
[Music]

450
00:21:11,600 --> 00:21:09,240
the in terms of the inhibition high

451
00:21:12,470 --> 00:21:11,610
abundances first their water with

452
00:21:14,450 --> 00:21:12,480
Jupiter or whatever

453
00:21:16,160 --> 00:21:14,460
it seems like the criterion you

454
00:21:17,950 --> 00:21:16,170
described is basically a local criteria

455
00:21:20,510 --> 00:21:17,960
and the looks just very sort of you know

456
00:21:22,430 --> 00:21:20,520
you know instantaneous or not

457
00:21:24,230 --> 00:21:22,440
instantaneous Bavarian infinitesimal

458
00:21:25,640 --> 00:21:24,240
kind of perturbations given some local

459
00:21:27,290 --> 00:21:25,650
gradient and it seems like you can

460
00:21:29,360 --> 00:21:27,300
potentially get around that criterion if

461
00:21:32,090 --> 00:21:29,370
the convection is non-local like if you

462
00:21:34,130 --> 00:21:32,100
have external perturbations large-scale

463
00:21:37,130 --> 00:21:34,140

waves or whatever that push the parcel

464
00:21:40,310 --> 00:21:37,140
up by finite amount then basically

465
00:21:43,340 --> 00:21:40,320
condenses and then you can bring out the

466
00:21:44,810 --> 00:21:43,350
the condensate and so in that case you

467
00:21:46,430 --> 00:21:44,820
have removed the thing that inhibited

468
00:21:47,750 --> 00:21:46,440
the convection maybe the molecular mass

469
00:21:50,030 --> 00:21:47,760
drops back down to something approaching

470
00:21:51,560 --> 00:21:50,040
to and yet you're still retained the the

471
00:21:53,900 --> 00:21:51,570
latent heating effect which is the point

472
00:21:56,210 --> 00:21:53,910
factor so it seems like that could sort

473
00:22:00,470 --> 00:21:56,220
of circumvent the whole you know

474
00:22:04,070 --> 00:22:00,480
criterion what could what gives me some

475
00:22:06,110 --> 00:22:04,080
confidence I said that maybe you find

476
00:22:08,630 --> 00:22:06,120
the finite effect that you describe

477
00:22:12,590 --> 00:22:08,640
maybe needs to be too big is that

478
00:22:16,220 --> 00:22:12,600
actually so it seems to be observing

479
00:22:19,070 --> 00:22:16,230
some 2d in some to the

480
00:22:25,070 --> 00:22:19,080
Modelling so basically where you add the

481
00:22:28,400 --> 00:22:25,080
finite effects and and the other thing

482
00:22:31,070 --> 00:22:28,410
is so of course it's it's a long shot

483
00:22:33,260 --> 00:22:31,080
but there is some evidence that actually

484
00:22:36,200 --> 00:22:33,270
the the the great white film from Saturn

485
00:22:38,720 --> 00:22:36,210
the the spacing between them the time

486
00:22:42,049 --> 00:22:38,730
between them is actually consistent with

487
00:22:43,730 --> 00:22:42,059
exactly the prediction of this model

488
00:22:46,039 --> 00:22:43,740

because basically where you have this

489
00:22:50,570 --> 00:22:46,049
mobile gather the relative barrier it

490
00:22:52,789 --> 00:22:50,580
has some depth in pattern and the the

491
00:22:55,970 --> 00:22:52,799
relative timescale of the atmosphere

492
00:22:59,060 --> 00:22:55,980
above this buyer that is the decouple

493
00:23:01,909 --> 00:22:59,070
from the bottom is exactly the timescale

494
00:23:04,220 --> 00:23:01,919
between the two between two big

495
00:23:07,070 --> 00:23:04,230
eruptions and so basically that what we

496
00:23:10,120 --> 00:23:07,080
showed by Leon Ingersoll that you can

497
00:23:12,440 --> 00:23:10,130
actually have your big storm event

498
00:23:14,360 --> 00:23:12,450
heating up the atmosphere and you need

499
00:23:16,760 --> 00:23:14,370
exactly to cool down just the this

500
00:23:19,340 --> 00:23:16,770
atmosphere above this relative layer and

501
00:23:21,049 --> 00:23:19,350
then up you start up again and so you

502
00:23:26,890 --> 00:23:21,059
build on this in a gene that's why we

503
00:23:29,600 --> 00:23:26,900
have such great storms and pattern but

504
00:23:32,350 --> 00:23:29,610
yeah so there you mentioned the question

505
00:23:35,750 --> 00:23:32,360
about mixing entropy versus mixing

506
00:23:38,419 --> 00:23:35,760
temperature but the problem entropy is

507
00:23:40,850 --> 00:23:38,429
not conserved under mixing so so it's

508
00:23:44,000 --> 00:23:40,860
true that you want to shut off the

509
00:23:45,530 --> 00:23:44,010
mixing when you're on the 80 of that but

510
00:23:48,530 --> 00:23:45,540
but actually the thing that's conserved

511
00:23:50,060 --> 00:23:48,540
during convection is enthalpy yeah in

512
00:23:51,200 --> 00:23:50,070
mixing enthalpy but you don't want to

513
00:23:52,220 --> 00:23:51,210

mix enthalpy either because that's

514
00:23:53,930 --> 00:23:52,230
that's like missing temperature so

515
00:23:56,120 --> 00:23:53,940
actually the right thing to do I think

516
00:24:00,020 --> 00:23:56,130
it's to mix enthalpy but they have the

517
00:24:02,390 --> 00:24:00,030
kaze ed said go to zero as as the

518
00:24:04,490 --> 00:24:02,400
gradient entropy goes to zero so it's

519
00:24:08,450 --> 00:24:04,500
not I think neither neither of this

520
00:24:12,799 --> 00:24:08,460
mixing is quite right but no no some I

521
00:24:16,070 --> 00:24:12,809
mean well you make in the end if you

522
00:24:17,840 --> 00:24:16,080
have mixing you enthalpy is constant

523
00:24:19,430 --> 00:24:17,850
even though it's not concert in the

524
00:24:22,070 --> 00:24:19,440
beginning to the end but that's a train

525
00:24:24,020 --> 00:24:22,080
but it go to defuse it defusing entropy

526
00:24:25,820 --> 00:24:24,030
leads to the case where your entropy

527
00:24:28,039 --> 00:24:25,830
your integrated entry is the same at the

528
00:24:29,810 --> 00:24:28,049
beginning in the end so that that's why

529
00:24:31,670 --> 00:24:29,820
if you just do KZ Ed's Edwin

530
00:24:35,720 --> 00:24:31,680
it'll give you the rider that's not what

531
00:24:37,520 --> 00:24:35,730
I did tell ya I mean Here I am NOT

532
00:24:40,730 --> 00:24:37,530
putting any numerical models it's

533
00:24:43,010 --> 00:24:40,740
actually only an icicle things what I'm

534
00:24:47,420 --> 00:24:43,020
just showing and I mean you can look at

535
00:24:49,520 --> 00:24:47,430
the paper there is a just a proven

536
00:24:52,190 --> 00:24:49,530
theorem you take the equations and you

537
00:24:54,560 --> 00:24:52,200
can show that in an atmosphere where

538
00:24:58,460 --> 00:24:54,570

when you are in the stable region if you

539
00:25:00,710 --> 00:24:58,470
do mix you will actually have tracked

540
00:25:05,870 --> 00:25:00,720
down one so you will heat up the lower