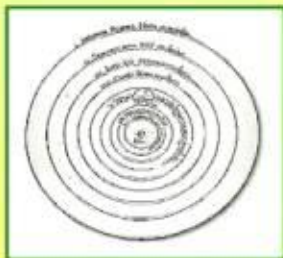


THE MEDIOCRITY PRINCIPLE



The solar system and life on Earth are about average and life will develop by the same rules wherever the proper conditions and the needed time are given.



1
00:00:05,420 --> 00:00:03,740
okay then well hello everybody and

2
00:00:07,460 --> 00:00:05,430
welcome again to the University of

3
00:00:11,270 --> 00:00:07,470
Washington astrobiology seminar series

4
00:00:14,030 --> 00:00:11,280
for this spring order our guest today is

5
00:00:18,200 --> 00:00:14,040
Professor Siegfried Frank from Potsdam

6
00:00:20,170 --> 00:00:18,210
University and Siegfried has a very long

7
00:00:22,550 --> 00:00:20,180
history in both physics and geophysics

8
00:00:24,980 --> 00:00:22,560
he did his physics degree in the

9
00:00:28,550 --> 00:00:24,990
University of Leipzig and got his PhD in

10
00:00:30,500 --> 00:00:28,560
1978 he then said what he describes to

11
00:00:32,630 --> 00:00:30,510
me as a second PhD because this is

12
00:00:35,870 --> 00:00:32,640
required in the German system and

13
00:00:37,639 --> 00:00:35,880

eventually became a lecturer in 1984 at

14

00:00:39,590 --> 00:00:37,649

the Central Institute for physics of the

15

00:00:42,979 --> 00:00:39,600

earth in Potsdam after completing his

16

00:00:44,840 --> 00:00:42,989

second PhD in 1989 he was appointed as a

17

00:00:48,139 --> 00:00:44,850

professor of geology they are sorry

18

00:00:49,819 --> 00:00:48,149

geophysics and since 1997 he has worked

19

00:00:52,430 --> 00:00:49,829

at the Potsdam Institute for climate

20

00:00:55,430 --> 00:00:52,440

impact research in the field of Earth

21

00:00:57,170 --> 00:00:55,440

system analysis focusing on planetology

22

00:00:59,540 --> 00:00:57,180

and astrobiology with a particular

23

00:01:01,720 --> 00:00:59,550

interest in habitability and long-term

24

00:01:05,210 --> 00:01:01,730

habitability of terrestrial planets

25

00:01:07,130 --> 00:01:05,220

since 2004 he has been the professor of

26

00:01:09,289 --> 00:01:07,140

coevolution of the geosphere and

27

00:01:11,359 --> 00:01:09,299

biosphere at Potsdam University and

28

00:01:13,370 --> 00:01:11,369

today he will be talking to us about

29

00:01:15,230 --> 00:01:13,380

Earth system analysis and its

30

00:01:24,020 --> 00:01:15,240

applications to astrobiology so

31

00:01:26,960 --> 00:01:24,030

Siegfried is a gentleman yes I want the

32

00:01:29,780 --> 00:01:26,970

same wiki for inviting me to see Aaron

33

00:01:33,200 --> 00:01:29,790

and to help the possibility to give a

34

00:01:35,780 --> 00:01:33,210

talk so title of my talk was already

35

00:01:39,760 --> 00:01:35,790

announced I must say the title is not

36

00:01:43,719 --> 00:01:39,770

suspect to expect our crew lawyers and

37

00:01:47,149 --> 00:01:43,729

today we have said the day of zeros and

38

00:01:50,060 --> 00:01:47,159

I prefer that I should have used the

39

00:01:51,840 --> 00:01:50,070

title so search for second else at the

40

00:01:55,530 --> 00:01:51,850

day of zeros

41

00:01:59,280 --> 00:01:55,540

but this is it's not so hot very good

42

00:02:01,410 --> 00:01:59,290

but it describes a little bit so topic I

43

00:02:05,430 --> 00:02:01,420

want to speak about namely I have two

44

00:02:07,649 --> 00:02:05,440

parts first to investigate our planet

45

00:02:10,290 --> 00:02:07,659

Earth and the long term evolution of co

46

00:02:13,500 --> 00:02:10,300

biosphere the terms it was introduced by

47

00:02:15,660 --> 00:02:13,510

a gallon at ski so famous Roger of

48

00:02:18,930 --> 00:02:15,670

scientists and the second guilds was

49

00:02:23,970 --> 00:02:18,940

habitability and extrasolar planets so I

50

00:02:26,850 --> 00:02:23,980

have to pause next remark is a following

51
00:02:29,780 --> 00:02:26,860
that after this fits our discussion with

52
00:02:33,030 --> 00:02:29,790
your students and fiscal sponsor

53
00:02:35,400 --> 00:02:33,040
tf7 maybe my talk is too simple but

54
00:02:38,420 --> 00:02:35,410
really it told me that I should have a

55
00:02:41,610 --> 00:02:38,430
level for all students and so I hope

56
00:02:43,699 --> 00:02:41,620
this will not be the situations that you

57
00:02:46,949 --> 00:02:43,709
know all about is the Dyson's

58
00:02:53,940 --> 00:02:46,959
nevertheless I want to start with the

59
00:02:56,699 --> 00:02:53,950
next figure we do occur system analysis

60
00:03:00,330 --> 00:02:56,709
and Earth system analysis means to

61
00:03:03,240 --> 00:03:00,340
investigate earth as a system and if we

62
00:03:06,210 --> 00:03:03,250
do this that's a long time scales we

63
00:03:09,509 --> 00:03:06,220

investigate SAT us as a system of cell

64
00:03:12,930 --> 00:03:09,519
components and these components are for

65
00:03:17,009 --> 00:03:12,940
example the the deep interior of the

66
00:03:22,620 --> 00:03:17,019
girls oceanic crust the continental

67
00:03:26,280 --> 00:03:22,630
crust Z atmosphere see hydrosphere and

68
00:03:28,740 --> 00:03:26,290
of course the biosphere and in the

69
00:03:31,770 --> 00:03:28,750
framework of some modeling we try to

70
00:03:35,699 --> 00:03:31,780
investigate houses components develop

71
00:03:37,949 --> 00:03:35,709
under his okok external forcing and it's

72
00:03:41,430 --> 00:03:37,959
a case of the earth since external

73
00:03:45,509 --> 00:03:41,440
forcing is a insulation the radiation

74
00:03:47,400 --> 00:03:45,519
from the Sun changes over time as we

75
00:03:50,190 --> 00:03:47,410
know from the faint young Sun gumdrops

76

00:03:55,259 --> 00:03:50,200

Paul it's a case of extrasolar planets

77

00:04:00,370 --> 00:03:55,269

we have another central star and to do

78

00:04:07,720 --> 00:04:04,150

to investigate a process that is

79

00:04:12,160 --> 00:04:07,730

inversed in this in the action between

80

00:04:15,730 --> 00:04:12,170

central star and planet and this is a

81

00:04:18,000 --> 00:04:15,740

so-called global carbon cycle the global

82

00:04:20,470 --> 00:04:18,010

carbon cycle you know in how institute

83

00:04:22,690 --> 00:04:20,480

scientists investigate other the carpet

84

00:04:24,760 --> 00:04:22,700

cider but Charlotte I'm still for

85

00:04:27,940 --> 00:04:24,770

example is a car one-sided between a

86

00:04:29,140 --> 00:04:27,950

biosphere in the atmosphere the biasing

87

00:04:32,650 --> 00:04:29,150

of takes carbon from the atmosphere

88

00:04:36,880 --> 00:04:32,660

makes photosynthesis and creates biomass

89

00:04:40,990 --> 00:04:36,890

let's say of the 100 years such a tree

90

00:04:43,150 --> 00:04:41,000

can die and co2 goes back to the

91

00:04:45,790 --> 00:04:43,160

atmospheres is also a compensator but

92

00:04:48,670 --> 00:04:45,800

our carbon cycle has a very very long

93

00:04:51,550 --> 00:04:48,680

scale it describes the carbon in the

94

00:04:55,090 --> 00:04:51,560

atmosphere how it takes a greenhouse

95

00:04:59,020 --> 00:04:55,100

effect and it describes supposes of

96

00:05:01,530 --> 00:04:59,030

Vaseline that means co2 is dissolved in

97

00:05:05,020 --> 00:05:01,540

rain drops as Kaepernick passage and

98

00:05:07,680 --> 00:05:05,030

this carbonic acid in the eights with

99

00:05:10,870 --> 00:05:07,690

the silicates from the continents and

100

00:05:12,730 --> 00:05:10,880

was in this chemical reaction we have

101
00:05:16,390 --> 00:05:12,740
some products that are produced by a

102
00:05:18,930 --> 00:05:16,400
small rivers and larger rivers to

103
00:05:22,150 --> 00:05:18,940
deceive and this case carbon is

104
00:05:25,570 --> 00:05:22,160
transported from atmosphere to the ocean

105
00:05:28,270 --> 00:05:25,580
and in the ocean it can make certain

106
00:05:32,190 --> 00:05:28,280
reactions it can zero down the oceanic

107
00:05:36,220 --> 00:05:32,200
crust is transported to subduction zones

108
00:05:39,880 --> 00:05:36,230
here we have so-called metamorphic

109
00:05:42,010 --> 00:05:39,890
reactions in about 100 kilometer depths

110
00:05:46,420 --> 00:05:42,020
in a part of earth's back to the

111
00:05:49,630 --> 00:05:46,430
shortcut we are big hog or and acidic

112
00:05:52,540 --> 00:05:49,640
world car knows his atmosphere and the

113
00:05:55,180 --> 00:05:52,550

other particles down in the mantle and

114

00:05:58,360 --> 00:05:55,190

it's a framework of plate tectonics it

115

00:06:00,730 --> 00:05:58,370

may come back to the mid-ocean ridges it

116

00:06:04,240 --> 00:06:00,740

go again into the so-called surface

117

00:06:08,250 --> 00:06:04,250

reservoirs and this takes very very long

118

00:06:12,530 --> 00:06:08,260

f1 which mark a carbon atom this process

119

00:06:17,070 --> 00:06:12,540

would take about 800 900 million years

120

00:06:21,090 --> 00:06:17,080

but this is a suppressant carbon cycle

121

00:06:24,270 --> 00:06:21,100

and we have some knowledge or also some

122

00:06:27,240 --> 00:06:24,280

special population houses power cycle

123

00:06:29,580 --> 00:06:27,250

was in the past and we know it's a past

124

00:06:33,630 --> 00:06:29,590

according to the failure example docs

125

00:06:36,590 --> 00:06:33,640

cinema no cgt of Sassan was smaller of

126

00:06:40,830 --> 00:06:36,600

about 25 persons it's a present value

127

00:06:43,290 --> 00:06:40,840

but when it's a framework of system that

128

00:06:46,110 --> 00:06:43,300

was much more co2 in the atmosphere and

129

00:06:49,380 --> 00:06:46,120

the greenhouse effect was about four

130

00:06:53,400 --> 00:06:49,390

times the present thing but we know it's

131

00:06:59,190 --> 00:06:53,410

a archaean we had we had no such trees

132

00:07:01,460 --> 00:06:59,200

we had only microorganism so biofilms so

133

00:07:06,420 --> 00:07:01,470

there wasn't another process of soon

134

00:07:08,880 --> 00:07:06,430

biogenic part in the system and when she

135

00:07:11,400 --> 00:07:08,890

has I the continent ago I was a powered

136

00:07:14,730 --> 00:07:11,410

only ten percent of the present law and

137

00:07:17,790 --> 00:07:14,740

the spreading wage and have spreading

138

00:07:20,550 --> 00:07:17,800

rates have been much larger than today

139

00:07:23,160 --> 00:07:20,560

about four times as large shop on the

140

00:07:26,310 --> 00:07:23,170

other hand said mean mando temperature

141

00:07:29,760 --> 00:07:26,320

was about 200 degrees higher though

142

00:07:33,450 --> 00:07:29,770

these are values settling oven that we

143

00:07:36,120 --> 00:07:33,460

should recover with our other limit but

144

00:07:39,060 --> 00:07:36,130

we we don't not only look into the past

145

00:07:41,210 --> 00:07:39,070

but also into the future surely why was

146

00:07:45,170 --> 00:07:41,220

the spreading way to larger in the past

147

00:07:48,810 --> 00:07:45,180

because he the earth was much hotter and

148

00:07:50,880 --> 00:07:48,820

the heat flow was higher and the

149

00:07:56,670 --> 00:07:50,890

spelling late is related to the heat

150

00:08:00,870 --> 00:07:56,680

flow and we can expect the relate or

151
00:08:04,260 --> 00:08:00,880
even happily how will be this coincided

152
00:08:08,940 --> 00:08:04,270
in about 1 million years the luminosity

153
00:08:12,840 --> 00:08:08,950
were grown up to about 10,000 100

154
00:08:15,180 --> 00:08:12,850
presently the greenhouse effect maybe

155
00:08:18,390 --> 00:08:15,190
about only ninety percent of the present

156
00:08:21,300 --> 00:08:18,400
value because there's less co2 its

157
00:08:24,360 --> 00:08:21,310
atmosphere we don't know what will be in

158
00:08:26,640 --> 00:08:24,370
1,000,000 year was a biosphere how will

159
00:08:29,210 --> 00:08:26,650
it look and what type of biosphere will

160
00:08:32,610 --> 00:08:29,220
be sad if seconded escrows was a

161
00:08:37,440 --> 00:08:32,620
seven-second rain they will have an era

162
00:08:40,920 --> 00:08:37,450
of 40,000 not reciprocated and the mango

163
00:08:45,510 --> 00:08:40,930

temperature would have lower bound for

164

00:08:53,010 --> 00:08:45,520

about 50 degrees Kelvin those this is to

165

00:08:55,650 --> 00:08:53,020

long-term future and now the picture I

166

00:08:59,010 --> 00:08:55,660

showed you was the clothes hamper tiger

167

00:09:02,820 --> 00:08:59,020

in the in the language of geoscientists

168

00:09:06,300 --> 00:09:02,830

few physicists and churches and

169

00:09:08,220 --> 00:09:06,310

monologist but here I have this same

170

00:09:10,680 --> 00:09:08,230

cycle in the language of a mother love

171

00:09:14,520 --> 00:09:10,690

and hear of a mathematician it's the

172

00:09:17,880 --> 00:09:14,530

same which I just showed us a pic just

173

00:09:21,720 --> 00:09:17,890

before here we have is a world box model

174

00:09:26,450 --> 00:09:21,730

there we have six boxes namely a box

175

00:09:30,660 --> 00:09:26,460

atmosphere and ocean continent seafloor

176

00:09:34,950 --> 00:09:30,670

mantle biosphere and you know if

177

00:09:37,770 --> 00:09:34,960

biosphere guys nuts LOL how one was

178

00:09:40,580 --> 00:09:37,780

pegged to the atmosphere in since the

179

00:09:43,890 --> 00:09:40,590

cane but there is a deposition of

180

00:09:46,770 --> 00:09:43,900

organic of the Jews carbon let's add one

181

00:09:51,210 --> 00:09:46,780

person and this is called corrosion and

182

00:09:56,490 --> 00:09:51,220

this is steep resilient organic carbon

183

00:09:59,040 --> 00:09:56,500

so we have six boxes and so carbon cycle

184

00:10:01,230 --> 00:09:59,050

consists of six change of carbon which

185

00:10:05,280 --> 00:10:01,240

means these boxes by various processes

186

00:10:08,250 --> 00:10:05,290

which are in here and the mathematician

187

00:10:09,650 --> 00:10:08,260

which right now Aziz differential

188

00:10:14,680 --> 00:10:09,660

equation

189

00:10:17,990 --> 00:10:14,690

six courses anchor ocean-atmosphere

190

00:10:21,290 --> 00:10:18,000

continents ocean floor biosphere

191

00:10:23,960 --> 00:10:21,300

pollution and this is a equation

192

00:10:26,600 --> 00:10:23,970

describing the cooling down of samandar

193

00:10:30,200 --> 00:10:26,610

and calculating is as heat flux which

194

00:10:35,600 --> 00:10:30,210

you ask for for using it to describe the

195

00:10:39,410 --> 00:10:35,610

spread of it so I show you a little bit

196

00:10:44,960 --> 00:10:39,420

larger simulation for example this term

197

00:10:48,500 --> 00:10:44,970

here this is a recasting this very

198

00:10:51,470 --> 00:10:48,510

native subtext noise so every term is

199

00:10:54,410 --> 00:10:51,480

related to result in browsers today I

200

00:10:56,630 --> 00:10:54,420

cannot explain all supposes Imperial

201
00:10:59,900 --> 00:10:56,640
because lack of time so i will show you

202
00:11:03,650 --> 00:10:59,910
it it a little bit quickly you can

203
00:11:07,700 --> 00:11:03,660
imagine that for example is this this is

204
00:11:10,070 --> 00:11:07,710
a mathematical expression for this I was

205
00:11:15,760 --> 00:11:10,080
this exchange for the sea floor to the

206
00:11:21,940 --> 00:11:18,740
weathering precipitation means the

207
00:11:25,700 --> 00:11:21,950
falling out carbonate of the ocean

208
00:11:28,960 --> 00:11:25,710
hypothermia reactions your title certain

209
00:11:35,920 --> 00:11:28,970
reactions take O₂ from the ocean and

210
00:11:40,640 --> 00:11:35,930
deposited at the sea floor and so on and

211
00:11:44,560 --> 00:11:40,650
now if we use the system of a grain we

212
00:11:48,560 --> 00:11:44,570
can calculate the time evolution of

213
00:11:51,500 --> 00:11:48,570

every reservoir of carbon or Walker's

214

00:11:57,400 --> 00:11:51,510

history and into the long-term future of

215

00:12:04,090 --> 00:11:57,410

zeros and this is shown here we have

216

00:12:09,560 --> 00:12:04,100

greed is imagine atmosphere ocean arete

217

00:12:15,080 --> 00:12:09,570

ocean floors blue kelby display is here

218

00:12:18,100 --> 00:12:15,090

and continents our agenda though we have

219

00:12:22,140 --> 00:12:18,110

some special features for example said

220

00:12:25,310 --> 00:12:22,150

cheering is an object of illusion of say

221

00:12:29,880 --> 00:12:25,320

because of increasing solar luminosity

222

00:12:32,940 --> 00:12:29,890

co2 is transferred from zur from the

223

00:12:35,760 --> 00:12:32,950

service was over after Samantha SVC uses

224

00:12:38,340 --> 00:12:35,770

and the other reservoirs have is a

225

00:12:41,490 --> 00:12:38,350

certain kind of illusion I don't want to

226

00:12:45,840 --> 00:12:41,500

Speak about a detail at this point but

227

00:12:49,410 --> 00:12:45,850

You have to believe me that this is a

228

00:12:53,390 --> 00:12:49,420

reside and we can use single reside for

229

00:12:57,090 --> 00:12:53,400

example for calculating atmospheric CO₂

230

00:12:59,490 --> 00:12:57,100

which is here so what we have some

231

00:13:02,910 --> 00:12:59,500

channel other side said in the arc here

232

00:13:05,250 --> 00:13:02,920

We had a high level of CO₂ in the

233

00:13:07,980 --> 00:13:05,260

atmosphere because solar luminosity was

234

00:13:11,160 --> 00:13:07,990

low and this comes down with evolution

235

00:13:14,880 --> 00:13:11,170

into the future this is today since the

236

00:13:19,470 --> 00:13:14,890

beginning this is today this is about

237

00:13:23,880 --> 00:13:19,480

two billion years inclusion and this

238

00:13:27,240 --> 00:13:23,890

creation area means that within this era

239

00:13:29,700 --> 00:13:27,250

as a co2 content of the atmosphere cover

240

00:13:32,400 --> 00:13:29,710

spice to a lean closer surface

241

00:13:36,180 --> 00:13:32,410

temperature between 0 and 100 degrees

242

00:13:38,490 --> 00:13:36,190

Celsius this is a service temperatures a

243

00:13:40,980 --> 00:13:38,500

corresponding and we see according to

244

00:13:43,350 --> 00:13:40,990

the hunting and a growth model we had

245

00:13:45,930 --> 00:13:43,360

first such an effect but we has at very

246

00:13:48,900 --> 00:13:45,940

high temperature but send ten pollutions

247

00:13:50,910 --> 00:13:48,910

went down and had present clear is it

248

00:13:53,780 --> 00:13:50,920

geological sense we have a minimum of

249

00:13:56,520 --> 00:13:53,790

atmospheric co2 and is a few or

250

00:13:59,700 --> 00:13:56,530

atmosphere surface temperature and in

251
00:14:03,510 --> 00:13:59,710
the future it will be again to higher

252
00:14:06,740 --> 00:14:03,520
levels this is a point I have done well

253
00:14:11,400 --> 00:14:06,750
to speech teacher since a ratio of

254
00:14:15,510 --> 00:14:11,410
carbon in z KO game in his accompanies

255
00:14:18,510 --> 00:14:15,520
it means same ratio of opening to an

256
00:14:23,330 --> 00:14:18,520
organic carbon which was investigated

257
00:14:28,410 --> 00:14:23,340
atomizer main famous german

258
00:14:32,460 --> 00:14:28,420
geoscientists from mines and

259
00:14:37,190 --> 00:14:32,470
and here we say senses it's about this

260
00:14:41,910 --> 00:14:37,200
ratio is about 124 that means one

261
00:14:48,329 --> 00:14:41,920
organic atom of carbon corresponds to

262
00:14:52,740 --> 00:14:48,339
floor inorganic carbon atoms Loski was

263
00:14:56,970 --> 00:14:52,750

the name of this man and Jesus this

264

00:15:03,420 --> 00:14:56,980

curve is taken from zurn from the famous

265

00:15:08,069 --> 00:15:03,430

book of of seller American scientist who

266

00:15:10,500 --> 00:15:08,079

was in in New York she's mackage

267

00:15:12,480 --> 00:15:10,510

testicle is probably clear the only

268

00:15:14,850 --> 00:15:12,490

things that is changing with time in

269

00:15:18,560 --> 00:15:14,860

your model is the heat flux from the

270

00:15:20,910 --> 00:15:18,570

earth and the Sun loom insulation Z zaza

271

00:15:24,079 --> 00:15:20,920

internal and external forcing is the

272

00:15:29,250 --> 00:15:24,089

only forcing and and of course as a SI

273

00:15:31,470 --> 00:15:29,260

era of continents its air of continents

274

00:15:33,150 --> 00:15:31,480

so you take that as from the geological

275

00:15:36,509 --> 00:15:33,160

record I take it from the cheer logical

276

00:15:39,630 --> 00:15:36,519

record Mike come back to this is your

277

00:15:42,389 --> 00:15:39,640

the carbon fractionation kerrigan go

278

00:15:45,720 --> 00:15:42,399

from zero to sort of a step increase at

279

00:15:50,329 --> 00:15:45,730

maybe three because you're from from

280

00:15:53,370 --> 00:15:50,339

zero because it's a at the beginning we

281

00:15:56,009 --> 00:15:53,380

we have no no biosphere but not no big

282

00:16:00,449 --> 00:15:56,019

biosphere they're just turning on the

283

00:16:02,970 --> 00:16:00,459

bastard yes this is a mathematical I'll

284

00:16:07,170 --> 00:16:02,980

be shocked but here it is about this but

285

00:16:15,990 --> 00:16:07,180

say queuing time how it says in in Azure

286

00:16:21,700 --> 00:16:18,790

and open chain is not included it's too

287

00:16:24,670 --> 00:16:21,710

small voices because he's effect because

288

00:16:28,450 --> 00:16:24,680

you knows it so let's say 100 years of

289

00:16:33,360 --> 00:16:28,460

top of a chain introduction of co2 to

290

00:16:45,070 --> 00:16:40,450

10 or 50 million years a time step this

291

00:16:47,830 --> 00:16:45,080

is a real global warming at UT today we

292

00:16:49,990 --> 00:16:47,840

had ravines and San lowest mean bit

293

00:16:52,930 --> 00:16:50,000

lower surface temperature and of course

294

00:16:56,110 --> 00:16:52,940

we we have been asked by people oh if

295

00:16:59,950 --> 00:16:56,120

this is right you may be a let's say

296

00:17:03,100 --> 00:16:59,960

somebody is in said can speak for quando

297

00:17:05,500 --> 00:17:03,110

você need input function of co2 but

298

00:17:07,620 --> 00:17:05,510

since the argument is a following the

299

00:17:10,270 --> 00:17:07,630

main problem of Underwood Cheney

300

00:17:14,890 --> 00:17:10,280

introduction of co2 to the atmosphere is

301
00:17:17,710 --> 00:17:14,900
a rate and the rate is about 100 times

302
00:17:22,300 --> 00:17:17,720
higher since a natural way from where

303
00:17:25,900 --> 00:17:22,310
canes this is if mankind would burn them

304
00:17:28,390 --> 00:17:25,910
says so first year feels very slowly

305
00:17:30,550 --> 00:17:28,400
like it was synthesized in nature it

306
00:17:34,450 --> 00:17:30,560
would be nonprofit not involvement but

307
00:17:37,990 --> 00:17:34,460
the rate is a problem right one more

308
00:17:39,700 --> 00:17:38,000
quick question at the end of the run

309
00:17:41,770 --> 00:17:39,710
away temperature presumably this is

310
00:17:44,200 --> 00:17:41,780
caused by the death of ruling plants and

311
00:17:50,050 --> 00:17:44,210
so you know how to get feedback from

312
00:17:53,020 --> 00:17:50,060
plant erosion and weathering well I mean

313
00:17:56,740 --> 00:17:53,030

I mean if you hit the main reason of

314

00:18:01,480 --> 00:17:56,750

this is is the increasing Sun you know

315

00:18:03,820 --> 00:18:01,490

at this time the system can make a poses

316

00:18:06,880 --> 00:18:03,830

of self-organization we have the

317

00:18:08,920 --> 00:18:06,890

increasing site and we say here the

318

00:18:13,450 --> 00:18:08,930

surface temperature is mainly determined

319

00:18:16,840 --> 00:18:13,460

by geophysics as a heat flow and by as a

320

00:18:19,600 --> 00:18:16,850

era of continents but here the

321

00:18:22,270 --> 00:18:19,610

increasing Sun overcomes all the other

322

00:18:25,270 --> 00:18:22,280

effects if you look at sir it's a

323

00:18:26,450 --> 00:18:25,280

certain where you send makes all other

324

00:18:29,000 --> 00:18:26,460

things

325

00:18:32,780 --> 00:18:29,010

don't and it gets worse the loss of

326

00:18:39,440 --> 00:18:32,790

biotic weather event this is a an

327

00:18:42,590 --> 00:18:39,450

additional effect but it is a picture I

328

00:18:46,970 --> 00:18:42,600

just showed you we had a very very rough

329

00:18:50,930 --> 00:18:46,980

by asleep we had a biosphere that had

330

00:18:55,010 --> 00:18:50,940

two properties it can exist between 0

331

00:18:57,550 --> 00:18:55,020

and 100 degree Celsius and the second

332

00:19:01,220 --> 00:18:57,560

condition is there must be an

333

00:19:06,980 --> 00:19:01,230

atmospheric co2 content of more than 10

334

00:19:13,820 --> 00:19:06,990

ppm co2 which is a lower limit for c4

335

00:19:15,410 --> 00:19:13,830

plants s supremum pious fair yes but we

336

00:19:19,010 --> 00:19:15,420

know it was a biosphere is more

337

00:19:22,400 --> 00:19:19,020

complicated and the other we introduced

338

00:19:26,680 --> 00:19:22,410

three types of biosphere namely walk re

339

00:19:33,250 --> 00:19:26,690

oats the most simple type of a biosphere

340

00:19:36,500 --> 00:19:33,260

which have no no or in the cell

341

00:19:40,910 --> 00:19:36,510

eukaryotes simple eukaryotes of watches

342

00:19:45,310 --> 00:19:40,920

which are one cell living beings wizard

343

00:19:49,420 --> 00:19:45,320

or and of course the complex biosphere

344

00:19:53,480 --> 00:19:49,430

which consists from my tea seller are

345

00:19:58,640 --> 00:19:53,490

complex living weeds and as grants

346

00:20:04,700 --> 00:19:58,650

animals function and for doing so

347

00:20:08,060 --> 00:20:04,710

muttering we introduce these three types

348

00:20:10,940 --> 00:20:08,070

and the temperature tolerance windows

349

00:20:13,460 --> 00:20:10,950

first this so she broke my oats are very

350

00:20:16,430 --> 00:20:13,470

robust these numbers come from

351
00:20:19,850 --> 00:20:16,440
discussions with academician servoz in

352
00:20:21,770 --> 00:20:19,860
from russian academy of sciences then

353
00:20:24,680 --> 00:20:21,780
eukaryotes are little bit more sensitive

354
00:20:27,340 --> 00:20:24,690
say it was say exists in this demo

355
00:20:31,550 --> 00:20:27,350
change and come next maricela life

356
00:20:35,420 --> 00:20:31,560
exists it says temperature range and as

357
00:20:36,530 --> 00:20:35,430
a sensitive sensitivity to co2 in the

358
00:20:39,980 --> 00:20:36,540
atmosphere

359
00:20:42,680 --> 00:20:39,990
same as a formal biosphere that means

360
00:20:47,770 --> 00:20:42,690
lower limit for photosynthesis is

361
00:20:51,590 --> 00:20:47,780
tempting p.m. and then we can model

362
00:21:00,250 --> 00:20:51,600
so-called biological productivity were

363
00:21:04,520 --> 00:21:00,260

these sweet types and we have a causal

364

00:21:07,670 --> 00:21:04,530

effect we take into account that the

365

00:21:11,840 --> 00:21:07,680

biosphere can have an additional effect

366

00:21:14,060 --> 00:21:11,850

on whether it can enhance weathering and

367

00:21:16,490 --> 00:21:14,070

this is described by this because this

368

00:21:19,940 --> 00:21:16,500

is a usual formula for weathering this

369

00:21:27,170 --> 00:21:19,950

activity of protons and this is Iranian

370

00:21:29,090 --> 00:21:27,180

factor and we assumed that the sea boca

371

00:21:31,700 --> 00:21:29,100

yachts and eukaryotes have known

372

00:21:36,140 --> 00:21:31,710

additional effect of wrestling if we put

373

00:21:41,510 --> 00:21:36,150

in here 14 theta 1 and theta 2 we have

374

00:21:44,150 --> 00:21:41,520

one but Sir the complex life-forms have

375

00:21:48,230 --> 00:21:44,160

a additional effect on Wesley we can't

376

00:21:52,280 --> 00:21:48,240

imagine for example that the tree has a

377

00:21:58,560 --> 00:21:52,290

strong effect on measuring by by

378

00:22:09,039 --> 00:22:04,690

and if we look at the results we see

379

00:22:10,899 --> 00:22:09,049

here is a time from 3.5 billion years in

380

00:22:13,840 --> 00:22:10,909

the past this is today it is a future

381

00:22:16,930 --> 00:22:13,850

and scizzin Sammy global surface thermal

382

00:22:19,840 --> 00:22:16,940

analysis Creed curve and we see it's a

383

00:22:23,680 --> 00:22:19,850

Arkin he had very high temperatures and

384

00:22:26,110 --> 00:22:23,690

this is it quickly cream and which with

385

00:22:32,049 --> 00:22:26,120

observations from canal and river from a

386

00:22:39,789 --> 00:22:32,059

lot which observed oxygen isotopes oh 16

387

00:22:41,830 --> 00:22:39,799

or 18 ratios and then it fall down this

388

00:22:43,509 --> 00:22:41,840

is a continent growth model for cells

389

00:22:47,289 --> 00:22:43,519

are calling the countries we have some

390

00:22:53,919 --> 00:22:47,299

periods of enhance and not so strong

391

00:22:58,720 --> 00:22:53,929

continental crows yep and NZ's effects

392

00:23:02,379 --> 00:22:58,730

are connected to seize this is Avenged

393

00:23:05,019 --> 00:23:02,389

is a continental growth and here we have

394

00:23:07,090 --> 00:23:05,029

effects and we have two stable solutions

395

00:23:10,810 --> 00:23:07,100

an upper and a lower this upper and

396

00:23:14,440 --> 00:23:10,820

lower temperature and then we have here

397

00:23:18,820 --> 00:23:14,450

is effects a couple explosion that goes

398

00:23:24,129 --> 00:23:18,830

down this is today and then we have the

399

00:23:26,560 --> 00:23:24,139

future and here we have certain secure

400

00:23:31,299 --> 00:23:26,570

relief biosphere boys it means the

401
00:23:34,750 --> 00:23:31,309
biomass red means from prokaryotes Creed

402
00:23:37,090 --> 00:23:34,760
from eukaryotes proud from complex

403
00:23:39,519 --> 00:23:37,100
multicellular life so it's a beginning

404
00:23:41,399 --> 00:23:39,529
we are normally work on yachts here

405
00:23:44,009 --> 00:23:41,409
there's an appearance of eukaryotes and

406
00:23:48,960 --> 00:23:44,019
since is really a Cambrian explosion

407
00:23:54,070 --> 00:23:48,970
explosion like some say complex life

408
00:23:57,310 --> 00:23:54,080
organism come into play and then they go

409
00:24:00,279 --> 00:23:57,320
down to take we have nearly one-third of

410
00:24:04,029 --> 00:24:00,289
sis box out of six work services and in

411
00:24:05,440 --> 00:24:04,039
future this part comes down that

412
00:24:10,840 --> 00:24:05,450
eukaryotes

413
00:24:15,279 --> 00:24:10,850

at least so 0 comments this girl is

414

00:24:17,529 --> 00:24:15,289

atmospheric oxygen content but because

415

00:24:20,080 --> 00:24:17,539

lack of staff I don't want to discuss it

416

00:24:28,409 --> 00:24:20,090

here we can speak about this into the

417

00:24:32,200 --> 00:24:28,419

discussion and aziza results can be also

418

00:24:33,940 --> 00:24:32,210

illustrated here since stability diagram

419

00:24:38,320 --> 00:24:33,950

here we have this bio training

420

00:24:40,299 --> 00:24:38,330

enhancement factor here style we have

421

00:24:42,789 --> 00:24:40,309

found this enhancement factor for God's

422

00:24:45,549 --> 00:24:42,799

sake white 6 here we are only broke our

423

00:24:49,440 --> 00:24:45,559

yachts then comes a Greek our yachts and

424

00:24:53,529 --> 00:24:49,450

do play here is already metastable

425

00:24:55,840 --> 00:24:53,539

existence of Modi said all as possible

426

00:24:58,600 --> 00:24:55,850

here we have at least somebody said on

427

00:25:02,440 --> 00:24:58,610

earth but when they died out in the

428

00:25:05,370 --> 00:25:02,450

future yesterday the dying out of the

429

00:25:09,159 --> 00:25:05,380

complex life-forms is a usual form and

430

00:25:13,210 --> 00:25:09,169

not such an explosion like it's a past

431

00:25:16,419 --> 00:25:13,220

and this is so dying out of eukaryotes

432

00:25:18,430 --> 00:25:16,429

as a support team atif life spent that

433

00:25:24,310 --> 00:25:18,440

means a dying out of support islands and

434

00:25:29,970 --> 00:25:24,320

this has a good relation to serve to the

435

00:25:33,159 --> 00:25:29,980

famous cook of peter barton brownlee

436

00:25:37,299 --> 00:25:33,169

namely is the life and death of planet

437

00:25:41,440 --> 00:25:37,309

girls amplifier remember this book these

438

00:25:46,029 --> 00:25:41,450

puzzles also proposed that these types

439

00:25:51,039 --> 00:25:46,039

of biosphere died out in the Rose Bowl

440

00:25:52,930 --> 00:25:51,049

as I appeal first I owns the complex

441

00:25:56,019 --> 00:25:52,940

life-forms sends you high oats and at

442

00:25:58,720 --> 00:25:56,029

least support artists but according to

443

00:26:02,139 --> 00:25:58,730

algal cells there is no no complete

444

00:26:06,009 --> 00:26:02,149

symmetry because we say complex life

445

00:26:08,270 --> 00:26:06,019

forms tile is a usual way enough in the

446

00:26:12,650 --> 00:26:08,280

framework of a so-called Andy

447

00:26:15,500 --> 00:26:12,660

how we improve this Amelia the context

448

00:26:17,720 --> 00:26:15,510

platform is not like an implosion in

449

00:26:20,740 --> 00:26:17,730

relation to the explosion but is in the

450

00:26:25,880 --> 00:26:20,750

usual way as a eukaryotes the pier but

451

00:26:28,280 --> 00:26:25,890

this is this is a different the 3.6

452

00:26:30,140 --> 00:26:28,290

factor where does that come from

453

00:26:33,020 --> 00:26:30,150

obviously that's quite important as to

454

00:26:36,740 --> 00:26:33,030

what the value there is it's who you

455

00:26:38,630 --> 00:26:36,750

have of course may just it it it makes

456

00:26:41,870 --> 00:26:38,640

no qualitative but of course

457

00:26:45,470 --> 00:26:41,880

quantitative change and it was used to

458

00:26:50,300 --> 00:26:45,480

to make sense his time of sick ambien

459

00:26:52,640 --> 00:26:50,310

explosions 540 million years ago except

460

00:26:56,270 --> 00:26:52,650

at this time I scanned shifted a little

461

00:26:59,630 --> 00:26:56,280

bit so if you work at this failure you

462

00:27:02,000 --> 00:26:59,640

will believe me that is so we had the

463

00:27:04,280 --> 00:27:02,010

end of the virus here as proposed but of

464

00:27:08,320 --> 00:27:04,290

course we also can speculate about the

465

00:27:11,210 --> 00:27:08,330

end of sea pearls as a planet and in

466

00:27:13,880 --> 00:27:11,220

mainly dree hemingway our colleague Mike

467

00:27:16,520 --> 00:27:13,890

records for how it must be well also

468

00:27:19,130 --> 00:27:16,530

bought it is feared he located but start

469

00:27:22,760 --> 00:27:19,140

the thought the lifespan of signals as a

470

00:27:26,360 --> 00:27:22,770

blend and in last week there was an

471

00:27:28,340 --> 00:27:26,370

article by a car Klaus Baelish widow and

472

00:27:31,880 --> 00:27:28,350

the muscle scientists in monthly notice

473

00:27:34,550 --> 00:27:31,890

of service on omegle society about this

474

00:27:38,750 --> 00:27:34,560

problem and of course I cannot speak

475

00:27:43,970 --> 00:27:38,760

about sisters will be in about seven

476

00:27:47,780 --> 00:27:43,980

eight or so billion years 5 or 6 50 days

477

00:27:50,300 --> 00:27:47,790

you know the Sun becomes a red giant in

478

00:27:54,080 --> 00:27:50,310

about let's say five or six please and

479

00:27:56,930 --> 00:27:54,090

this is sin so good in my teeth end of

480

00:28:00,950 --> 00:27:56,940

Sir planet girls and now I come to the

481

00:28:03,680 --> 00:28:00,960

second part namely to the habitable

482

00:28:06,620 --> 00:28:03,690

zones and the search for a second girls

483

00:28:09,980 --> 00:28:06,630

and I use this picture from andhra nizam

484

00:28:12,920 --> 00:28:09,990

exit are we from this book so a little

485

00:28:16,730 --> 00:28:12,930

prince and if you read this book is a

486

00:28:19,100 --> 00:28:16,740

situation where the little prince

487

00:28:23,270 --> 00:28:19,110

ask a friend where he should settle down

488

00:28:25,549 --> 00:28:23,280

and the friend gives him sit rice to

489

00:28:29,090 --> 00:28:25,559

settle down on planet bills because the

490

00:28:31,549 --> 00:28:29,100

girls has a good reputation is this

491

00:28:35,390 --> 00:28:31,559

sense this book is the first definition

492

00:28:39,890 --> 00:28:35,400

of a habitable zone so far I used as a

493

00:28:43,190 --> 00:28:39,900

starting point of course in the

494

00:28:46,400 --> 00:28:43,200

scientific field definitions of saratoga

495

00:28:49,370 --> 00:28:46,410

zone starlet later in a more serious way

496

00:28:53,990 --> 00:28:49,380

for example 12 Ostrovsky and Sagan and

497

00:28:56,330 --> 00:28:54,000

others and it lay on Kim's a famous

498

00:28:58,760 --> 00:28:56,340

muddling bagels of heart and of course

499

00:29:04,070 --> 00:28:58,770

of chill costly and his colleagues and

500

00:29:06,890 --> 00:29:04,080

the definition of Sir habitable zone is

501
00:29:09,620 --> 00:29:06,900
here is a range of distances around the

502
00:29:11,660 --> 00:29:09,630
central star at his girls like planets

503
00:29:15,020 --> 00:29:11,670
maintain conditions supplement for the

504
00:29:20,500 --> 00:29:15,030
existence of leg it's a service this

505
00:29:24,740 --> 00:29:20,510
would use a between habitable zone and

506
00:29:28,520 --> 00:29:24,750
of course for doing this we have a

507
00:29:33,770 --> 00:29:28,530
simplified system model not as

508
00:29:36,530 --> 00:29:33,780
complicated vs 6s of us but it is

509
00:29:39,049 --> 00:29:36,540
sketched here we have of course not sir

510
00:29:41,299 --> 00:29:39,059
son but another central star and an

511
00:29:44,150 --> 00:29:41,309
internal forcing we have a continental

512
00:29:46,970 --> 00:29:44,160
cross button not such detailed like

513
00:29:50,180 --> 00:29:46,980

secondi model but maybe lineal goes or

514

00:29:52,549 --> 00:29:50,190

constant grunting Andrea tempt we

515

00:29:56,750 --> 00:29:52,559

calculate the heat flow ensor the

516

00:30:00,820 --> 00:29:56,760

physics behind this model is that the

517

00:30:04,070 --> 00:30:00,830

atmospheric content of such a planet has

518

00:30:06,850 --> 00:30:04,080

sources and sinks into piracy resources

519

00:30:09,650 --> 00:30:06,860

our work any sources which can be

520

00:30:13,100 --> 00:30:09,660

calculated from mythical he lives and

521

00:30:15,370 --> 00:30:13,110

spreading models since as a leveling

522

00:30:20,200 --> 00:30:15,380

which I explained already said

523

00:30:22,900 --> 00:30:20,210

carbonates and silly case of continents

524

00:30:24,590 --> 00:30:22,910

the egg in a chemical way wizard

525

00:30:27,290 --> 00:30:24,600

atmospheric co2

526
00:30:29,150 --> 00:30:27,300
and of course a biosphere takes out co2

527
00:30:31,880 --> 00:30:29,160
from the atmosphere and when it died it

528
00:30:34,810 --> 00:30:31,890
gives Feng to co2 to the atmosphere so

529
00:30:42,560 --> 00:30:34,820
this is a main idea which means yet such

530
00:30:45,860 --> 00:30:42,570
simplified models and heavy uses only

531
00:30:47,780 --> 00:30:45,870
model again for the girls when he's

532
00:30:50,030 --> 00:30:47,790
because we start with her with our solar

533
00:30:56,570 --> 00:30:50,040
system and later on you use linear

534
00:30:59,410 --> 00:30:56,580
models or constants and of course he is

535
00:31:03,830 --> 00:30:59,420
our definition of the habitable zone in

536
00:31:06,140 --> 00:31:03,840
our definition so happy Jabba's old is a

537
00:31:09,250 --> 00:31:06,150
range of distances around the central

538
00:31:12,590 --> 00:31:09,260

star they are biological what activity

539

00:31:16,310 --> 00:31:12,600

biological productivity is a biomass say

540

00:31:20,540 --> 00:31:16,320

this or juice and a blend the unit of

541

00:31:23,390 --> 00:31:20,550

service and very humid of time and he

542

00:31:26,120 --> 00:31:23,400

been sponsored must ferry co2 and Hudson

543

00:31:29,210 --> 00:31:26,130

and 20 service temperature is larger

544

00:31:31,250 --> 00:31:29,220

sense hero when biological activity is

545

00:31:35,450 --> 00:31:31,260

larger seoane we also have each other's

546

00:31:38,200 --> 00:31:35,460

own here is 0 because it is too hot here

547

00:31:42,110 --> 00:31:38,210

this year because you should occur and

548

00:31:45,290 --> 00:31:42,120

he was a temperature in toggle between 0

549

00:31:48,640 --> 00:31:45,300

and 100 degrees again 10 ppm as a

550

00:31:52,580 --> 00:31:48,650

minimum and from Paula metrological

551
00:31:56,330 --> 00:31:52,590
documents we also get health and maximum

552
00:32:06,350 --> 00:32:01,669
and when we apply this model for the

553
00:32:08,990 --> 00:32:06,360
solar system we have fears and son he

554
00:32:13,430 --> 00:32:09,000
has Venus he has pearls and here's Mars

555
00:32:16,100 --> 00:32:13,440
and this is to tame this is 1 billion

556
00:32:21,430 --> 00:32:16,110
here in the past this is 1 billion years

557
00:32:23,870 --> 00:32:21,440
of future and what do we see this is a

558
00:32:27,470 --> 00:32:23,880
lower boundary of sahab each other's

559
00:32:30,799 --> 00:32:27,480
soul and it shifts slowly out how to his

560
00:32:34,730 --> 00:32:30,809
time and of course this is to understand

561
00:32:37,940 --> 00:32:34,740
because self so solar luminosity crows

562
00:32:41,120 --> 00:32:37,950
son it becomes hotter and the inner

563
00:32:45,019 --> 00:32:41,130

boundary shifts out what because comes

564

00:32:47,299 --> 00:32:45,029

to what at such a place and up to this

565

00:32:49,340 --> 00:32:47,309

time this is also the case for the outer

566

00:32:53,720 --> 00:32:49,350

boundary and also it's a models of

567

00:32:55,730 --> 00:32:53,730

Jocasta we have assist but here the

568

00:32:59,799 --> 00:32:55,740

country's growth of countenance comes

569

00:33:03,680 --> 00:32:59,809

into play so if the countenance crows

570

00:33:06,110 --> 00:33:03,690

the kunene and Ella makes more air for

571

00:33:09,889 --> 00:33:06,120

chemical weathering rich if we have

572

00:33:13,340 --> 00:33:09,899

larger continent here and so more co2 is

573

00:33:16,549 --> 00:33:13,350

taken out from the atmosphere as l4z the

574

00:33:21,980 --> 00:33:16,559

outer boundary shifts in god this is

575

00:33:24,620 --> 00:33:21,990

today and and then we have a point where

576

00:33:27,529 --> 00:33:24,630

as a habitable zone vanishes and this is

577

00:33:30,680 --> 00:33:27,539

a pretty much obliged spell I'd be it

578

00:33:34,789 --> 00:33:30,690

can imagine that if it said it also

579

00:33:37,250 --> 00:33:34,799

could be shifted about eight ten

580

00:33:39,710 --> 00:33:37,260

thousand ball that the present distant

581

00:33:43,210 --> 00:33:39,720

from the Sun the way then it would be

582

00:33:47,419 --> 00:33:43,220

assists let's say optimum distance yeah

583

00:33:49,970 --> 00:33:47,429

it's this way it leaves a big episode

584

00:33:54,350 --> 00:33:49,980

and say no boundary about 500 business

585

00:33:57,560 --> 00:33:54,360

this money and we see in the present

586

00:34:00,980 --> 00:33:57,570

time only zeros it's a habitable zone

587

00:34:02,820 --> 00:34:00,990

it's near Z Z a no boundary but we

588

00:34:05,940 --> 00:34:02,830

should be careful 1 billion years

589

00:34:07,860 --> 00:34:05,950

go we cannot say Mars was habitable have

590

00:34:11,010 --> 00:34:07,870

each other because it's model host 40

591

00:34:15,810 --> 00:34:11,020

sleep we must say correctly 1 billion

592

00:34:18,599 --> 00:34:15,820

years ago the planet Earth it's a

593

00:34:22,550 --> 00:34:18,609

present position of Mars which happening

594

00:34:25,710 --> 00:34:22,560

habita yes this would be the correct

595

00:34:27,750 --> 00:34:25,720

answer for this week we should have the

596

00:34:35,550 --> 00:34:27,760

planetary evolution with a especially

597

00:34:38,010 --> 00:34:35,560

for Mars and investigates and if we go

598

00:34:40,440 --> 00:34:38,020

to other central stars now I can this

599

00:34:42,540 --> 00:34:40,450

may quickly we should yourself from Gaza

600

00:34:45,030 --> 00:34:42,550

diet transit means the luminosity

601
00:34:50,099 --> 00:34:45,040
temperature relations independence of

602
00:34:54,060 --> 00:34:50,109
sis Thomas and you know low mass central

603
00:34:55,619 --> 00:34:54,070
stars are very very long on the main

604
00:34:58,740 --> 00:34:55,629
sequence this is the main sequence

605
00:35:01,530 --> 00:34:58,750
answer the difference between these

606
00:35:04,500 --> 00:35:01,540
point is 1 billion years here is the Sun

607
00:35:08,370 --> 00:35:04,510
it's 4.6 billion years old and it says

608
00:35:11,099 --> 00:35:08,380
about the same time it's a future on the

609
00:35:14,329 --> 00:35:11,109
main sequence and we also have self if

610
00:35:19,410 --> 00:35:14,339
we have more massive star for example

611
00:35:22,020 --> 00:35:19,420
the two so llamas saddle star is only a

612
00:35:25,079 --> 00:35:22,030
little bit more than 1 billion years as

613
00:35:28,800 --> 00:35:25,089

the main spirits short I'm intimate

614

00:35:33,540 --> 00:35:28,810

secrets it's not in use for you as a

615

00:35:37,670 --> 00:35:33,550

physicist and so we can calculate this

616

00:35:40,050 --> 00:35:37,680

is habitable zone for all different

617

00:35:44,370 --> 00:35:40,060

samples Thomas's here we have an example

618

00:35:46,170 --> 00:35:44,380

for for a solo mas but not sir Colleen

619

00:35:49,349 --> 00:35:46,180

and her crows model of Conde butter

620

00:35:51,900 --> 00:35:49,359

simple model and we have again this

621

00:35:53,970 --> 00:35:51,910

effects and at this point we have a

622

00:35:55,050 --> 00:35:53,980

shrinking of the auto Pollux a habitable

623

00:35:59,130 --> 00:35:55,060

zone

624

00:36:03,480 --> 00:35:59,140

nice spot for eighty percent central

625

00:36:07,100 --> 00:36:03,490

star the habitable zone is more kneel to

626

00:36:10,050 --> 00:36:07,110

the central star and it does not shift

627

00:36:13,800 --> 00:36:10,060

so very much but here we have against is

628

00:36:16,430 --> 00:36:13,810

a thing but for 120,000 central stop the

629

00:36:19,290 --> 00:36:16,440

heavy jeppesen is more outward that one

630

00:36:21,960 --> 00:36:19,300

astronomical unit yeah this is a

631

00:36:25,890 --> 00:36:21,970

distance in astronomical units but

632

00:36:28,590 --> 00:36:25,900

according to the short lifetime when the

633

00:36:36,230 --> 00:36:28,600

main sequence star stopped because at

634

00:36:40,560 --> 00:36:36,240

this point the Sun becomes a red dwarf I know

635

00:36:43,320 --> 00:36:40,570

we could use this and now I come to a

636

00:36:46,440 --> 00:36:43,330

next point namely the so called dynamic

637

00:36:49,050 --> 00:36:46,450

earth habitable zone up to now we did

638

00:36:52,770 --> 00:36:49,060

not investigate extrasolar planetary

639

00:36:56,670 --> 00:36:52,780

systems in a special way but if we look

640

00:36:59,850 --> 00:36:56,680

at special extrasolar planetary systems

641

00:37:02,460 --> 00:36:59,860

whether i was at one extrasolar planets

642

00:37:07,140 --> 00:37:02,470

so maybe is in effect let's say is a

643

00:37:10,680 --> 00:37:07,150

giant planet like here that has a

644

00:37:18,210 --> 00:37:10,690

cavitation influence once a habitable

645

00:37:21,240 --> 00:37:18,220

zone and for example he can force that

646

00:37:23,430 --> 00:37:21,250

there are unstable orbits of other

647

00:37:27,300 --> 00:37:23,440

planets within this range in his

648

00:37:31,470 --> 00:37:27,310

neighborhood and the rest of saboteurs

649

00:37:33,930 --> 00:37:31,480

own is called the dynamical habitable

650

00:37:36,320 --> 00:37:33,940

sworn so usually to dynamic the

651

00:37:38,910 --> 00:37:36,330

habitable zone is wall of the answer

652

00:37:41,190 --> 00:37:38,920

since the ordinary habitable zone at

653

00:37:44,430 --> 00:37:41,200

least it could be the same where you if

654

00:37:47,160 --> 00:37:44,440

this is more outward it's I think it's

655

00:37:50,040 --> 00:37:47,170

to understand to calculates a dynamical

656

00:37:53,250 --> 00:37:50,050

habitable zone and this wage can be

657

00:37:59,550 --> 00:37:53,260

calculated with help of the few radius

658

00:38:04,050 --> 00:37:59,560

of cysteine planets and we have used a

659

00:38:07,330 --> 00:38:04,060

catalog and found 86 XO planetary

660

00:38:11,770 --> 00:38:07,340

systems where we find all the data flow

661

00:38:14,320 --> 00:38:11,780

mass of the giant planets and and mass

662

00:38:16,660 --> 00:38:14,330

and luminosity in age of central star

663

00:38:19,570 --> 00:38:16,670

and effective radiation temperature

664

00:38:26,070 --> 00:38:19,580

which we needed to do the calculation

665

00:38:29,910 --> 00:38:26,080

and from these 86 investigated systems

666

00:38:35,740 --> 00:38:29,920

we found that more than sixty percent

667

00:38:38,320 --> 00:38:35,750

have a non resin vanishing widths of the

668

00:38:41,890 --> 00:38:38,330

dynamic habitable zone when I was a

669

00:38:44,550 --> 00:38:41,900

dynamic habitable zone as a usual but

670

00:38:47,920 --> 00:38:44,560

under the condition that there are no

671

00:38:53,470 --> 00:38:47,930

cavitation a lot of patience of orbits

672

00:38:57,880 --> 00:38:53,480

of possible just like models and here is

673

00:39:01,510 --> 00:38:57,890

the age of sea systems and here are the

674

00:39:06,340 --> 00:39:01,520

names of sea systems and we investigated

675

00:39:12,340 --> 00:39:06,350

earth-like planets with a constant ratio

676
00:39:14,710 --> 00:39:12,350
of continents and oceans here we have

677
00:39:17,050 --> 00:39:14,720
only ten twenty or thirty percent

678
00:39:20,500 --> 00:39:17,060
countenance these are so-called water

679
00:39:23,470 --> 00:39:20,510
wells like in the movie of Kevin Costner

680
00:39:25,240 --> 00:39:23,480
and these are land worlds where we have

681
00:39:27,940 --> 00:39:25,250
90 pills and continents and this has a

682
00:39:30,370 --> 00:39:27,950
strong influence on habitability as we

683
00:39:33,510 --> 00:39:30,380
found her and here he sees these colors

684
00:39:36,370 --> 00:39:33,520
and we see said always the water worlds

685
00:39:40,270 --> 00:39:36,380
have a larger width of the dynamic

686
00:39:43,720 --> 00:39:40,280
habitable zone and the most important

687
00:39:50,500 --> 00:39:43,730
finding for us was effect said our solar

688
00:39:52,960 --> 00:39:50,510

system is at place 19 though if we use

689

00:39:56,310 --> 00:39:52,970

this definition that the width of said

690

00:39:59,140 --> 00:39:56,320

memory girl habitable zone is a measure

691

00:40:04,150 --> 00:39:59,150

let's say for the habitability in the

692

00:40:06,370 --> 00:40:04,160

system we found 18 systems that have

693

00:40:11,350 --> 00:40:06,380

better conditions for finding a second

694

00:40:15,070 --> 00:40:11,360

girls as an hour's hola system and this

695

00:40:17,790 --> 00:40:15,080

for us to the idea that this is a let's

696

00:40:20,300 --> 00:40:17,800

say manifestation of mediocrity

697

00:40:23,380 --> 00:40:20,310

principle which was introduced

698

00:40:27,820 --> 00:40:23,390

copernicus when he went from the

699

00:40:30,710 --> 00:40:27,830

geocentric to serve heliocentric system

700

00:40:32,630 --> 00:40:30,720

that he said the solar system and life

701
00:40:34,220 --> 00:40:32,640
when else are about average and live

702
00:40:36,440 --> 00:40:34,230
well developed by the same words but

703
00:40:39,170 --> 00:40:36,450
others of proper conditions and the

704
00:40:42,760 --> 00:40:39,180
needed time are given so earth is

705
00:40:47,960 --> 00:40:42,770
nothing special or solar system but it's

706
00:40:50,830 --> 00:40:47,970
media kriti now I come to the point of

707
00:40:55,180 --> 00:40:50,840
calculating the number of habitable

708
00:40:58,280 --> 00:40:55,190
planets in the Milky Way and the first

709
00:41:03,020 --> 00:40:58,290
way to do this is with a help of the

710
00:41:06,160 --> 00:41:03,030
famous Drake formula regístrate I he

711
00:41:09,080 --> 00:41:06,170
wanted to calculate a number of

712
00:41:11,420 --> 00:41:09,090
intelligent civilizations in the Milky

713
00:41:14,270 --> 00:41:11,430

Way and so he proposed to Doozers

714

00:41:17,150 --> 00:41:14,280

reserves his formula the total number of

715

00:41:19,000 --> 00:41:17,160

stars in the Milky Way times the

716

00:41:21,470 --> 00:41:19,010

fraction of stars that have planets

717

00:41:23,480 --> 00:41:21,480

times the fraction of stars that have

718

00:41:25,940 --> 00:41:23,490

girls like planets times the flight

719

00:41:28,670 --> 00:41:25,950

earth land planets at irons a habitable

720

00:41:31,970 --> 00:41:28,680

zone times a fraction of habitable

721

00:41:34,040 --> 00:41:31,980

planets developed life time the flexion

722

00:41:37,400 --> 00:41:34,050

of habitable planets that developed

723

00:41:39,950 --> 00:41:37,410

intelligent life times the fraction of

724

00:41:43,940 --> 00:41:39,960

intelligent life that develops radio

725

00:41:46,130 --> 00:41:43,950

technology and here's a normalized mean

726

00:41:49,400 --> 00:41:46,140

lifetime of an intelligent civilization

727

00:41:52,010 --> 00:41:49,410

you know this is a topic of discussions

728

00:41:58,670 --> 00:41:52,020

and every scientist can use its values

729

00:42:01,280 --> 00:41:58,680

but we proposed that for calculating the

730

00:42:05,510 --> 00:42:01,290

number of habitable planets he only

731

00:42:11,930 --> 00:42:05,520

needs a first four factors and these two

732

00:42:13,670 --> 00:42:11,940

have been mixed to one factor so we we

733

00:42:15,830 --> 00:42:13,680

found that according to the

734

00:42:18,620 --> 00:42:15,840

investigation of extra solar systems we

735

00:42:20,990 --> 00:42:18,630

have more experience about these values

736

00:42:24,440 --> 00:42:21,000

the number of total stars in the Milky

737

00:42:26,360 --> 00:42:24,450

Way is four hundred billions then we

738

00:42:30,070 --> 00:42:26,370

assumes it's a fraction of stars was

739

00:42:32,840 --> 00:42:30,080

earth-like planets is about 1% and this

740

00:42:33,980 --> 00:42:32,850

could be calculated from our

741

00:42:36,530 --> 00:42:33,990

investigations of

742

00:42:38,870 --> 00:42:36,540

beat ability I cannot show it in TJ

743

00:42:41,750 --> 00:42:38,880

right we could talk about this in the

744

00:42:44,840 --> 00:42:41,760

discussion and we found that there is a

745

00:42:47,060 --> 00:42:44,850

function of about 1.2 percent of

746

00:42:52,540 --> 00:42:47,070

earth-like planets in the habitable zone

747

00:42:58,820 --> 00:42:52,550

and this gives us a number of about

748

00:43:05,120 --> 00:42:58,830

eighty four or four hundred million four

749

00:43:08,690 --> 00:43:05,130

hundred eighty million voila 80-84 48

750

00:43:11,930 --> 00:43:08,700

million 50 about 50 million excuse me 84

751
00:43:15,380 --> 00:43:11,940
million of habitable planets in the

752
00:43:17,960 --> 00:43:15,390
Milky Way those is a rather simple

753
00:43:22,730 --> 00:43:17,970
calculation if you have another feeling

754
00:43:25,690 --> 00:43:22,740
of numbers you can put it in and but

755
00:43:28,880 --> 00:43:25,700
there's another method to calculate

756
00:43:31,280 --> 00:43:28,890
these number of habitable planet was out

757
00:43:33,920 --> 00:43:31,290
of a convolution in Dakar the

758
00:43:37,370 --> 00:43:33,930
convolution integral means it's a Time

759
00:43:40,520 --> 00:43:37,380
in the car where we calculate the number

760
00:43:43,400 --> 00:43:40,530
of habitable planets first from the

761
00:43:50,920 --> 00:43:43,410
planet formation rate at a certain time

762
00:43:56,690 --> 00:43:50,930
T prime times the probability that an

763
00:44:01,940 --> 00:43:56,700

earth-like planet that is that appeared

764

00:44:06,380 --> 00:44:01,950

at the time T prime is even in the

765

00:44:11,270 --> 00:44:06,390

habitable zone at a later time T this is

766

00:44:14,540 --> 00:44:11,280

this convolution and this could be taken

767

00:44:18,440 --> 00:44:14,550

for exam investigations of charles line

768

00:44:21,140 --> 00:44:18,450

available from sydney and this could be

769

00:44:23,660 --> 00:44:21,150

taken also i will not speak a teacher

770

00:44:25,700 --> 00:44:23,670

but if he takes his in dakar we have a

771

00:44:32,570 --> 00:44:25,710

number of habitable planets at yourself

772

00:44:35,120 --> 00:44:32,580

time t and here here we f this is planet

773

00:44:37,849 --> 00:44:35,130

formation rate normalized to the Milky

774

00:44:40,460 --> 00:44:37,859

Way so at this is presence is also

775

00:44:44,589 --> 00:44:40,470

Richmond to this big bang so at present

776

00:44:44,599 --> 00:44:56,329

about wow

777

00:44:56,339 --> 00:45:07,420

you have a planet formation rate of of

778

00:45:18,229 --> 00:45:15,709

0.10 a year and and here we have the

779

00:45:22,160 --> 00:45:18,239

calculated number of habitable planets

780

00:45:24,859 --> 00:45:22,170

and at the beginning we have no material

781

00:45:26,209 --> 00:45:24,869

so the planetary formation rate was zero

782

00:45:31,219 --> 00:45:26,219

and also is the number of her feet a bit

783

00:45:36,079 --> 00:45:31,229

less but then it came very high and it's

784

00:45:42,140 --> 00:45:36,089

down and now we have here a value in the

785

00:45:44,089 --> 00:45:42,150

all of let's say 30 million we had 48 in

786

00:45:48,529 --> 00:45:44,099

this is the calculation here 30 min and

787

00:45:50,989 --> 00:45:48,539

Wallace also interesting that new to the

788

00:45:52,940 --> 00:45:50,999

time of Earth or region we had a maximum

789

00:45:58,009 --> 00:45:52,950

number of habitable planets in the Milky

790

00:46:01,190 --> 00:45:58,019

Way exist for us to the idea that at

791

00:46:04,759 --> 00:46:01,200

least if panspermia in the stellar plans

792

00:46:08,200 --> 00:46:04,769

/ Mia was possible at all said it was

793

00:46:15,940 --> 00:46:08,210

most probable it's a time of also agent

794

00:46:24,859 --> 00:46:21,849

though we try to use this to to do some

795

00:46:30,259 --> 00:46:24,869

quantitative estimation sposa hello

796

00:46:32,930 --> 00:46:30,269

those hypotheses of the world and Donald

797

00:46:37,359 --> 00:46:32,940

Romney and we calculated so we're here

798

00:46:40,999 --> 00:46:37,369

real girls factor namely is a number of

799

00:46:44,349 --> 00:46:41,009

habitable planets which are appropriate

800

00:46:48,559 --> 00:46:44,359

for primitive life only to the number of

801
00:46:54,589 --> 00:46:48,569
habitable planets which are appropriate

802
00:46:58,400 --> 00:46:54,599
also for complex life and doing this we

803
00:47:01,190 --> 00:46:58,410
did a similar population like I have

804
00:47:03,769 --> 00:47:01,200
shown before we have the number of

805
00:47:08,390 --> 00:47:03,779
habitable planets here was primitive

806
00:47:09,270 --> 00:47:08,400
life and here with complex life here's

807
00:47:15,060 --> 00:47:09,280
Big Bang

808
00:47:18,120 --> 00:47:15,070
is today and we found a difference of 10

809
00:47:23,610 --> 00:47:18,130
to the power of 2 that means at present

810
00:47:26,580 --> 00:47:23,620
we have 100 times more planets this

811
00:47:29,340 --> 00:47:26,590
primitive life centers complex life but

812
00:47:32,420 --> 00:47:29,350
I should say that says is in any way a

813
00:47:35,340 --> 00:47:32,430

lower powered because there are a lot of

814

00:47:38,010 --> 00:47:35,350

factors that are discussed is a book by

815

00:47:41,280 --> 00:47:38,020

Peter water tunnel boundary that we up

816

00:47:45,290 --> 00:47:41,290

to now did not take into account givi

817

00:47:48,300 --> 00:47:45,300

took only into a current such a

818

00:47:52,830 --> 00:47:48,310

poisoning effect of too high co2 content

819

00:47:55,500 --> 00:47:52,840

and ends a sensibility to the

820

00:47:57,540 --> 00:47:55,510

temperature tolerance window one should

821

00:48:00,000 --> 00:47:57,550

take into account select or the

822

00:48:02,310 --> 00:48:00,010

existence of a magnetic field and into

823

00:48:05,330 --> 00:48:02,320

many under puzzle point so this is

824

00:48:08,420 --> 00:48:05,340

always a lower bound and in future

825

00:48:11,700 --> 00:48:08,430

estimations this number will become

826

00:48:16,320 --> 00:48:11,710

larger but it's remarkable that the

827

00:48:19,920 --> 00:48:16,330

ratio doesn't change that much over time

828

00:48:24,470 --> 00:48:19,930

that's said much yes and of course here

829

00:48:32,280 --> 00:48:28,440

hear this kid it is a oh no no I

830

00:48:36,330 --> 00:48:32,290

mean yes yeah do you mean sis yes yeah

831

00:48:43,370 --> 00:48:36,340

we go down if you take those two guys

832

00:48:48,090 --> 00:48:43,380

much more seriously than we do why I

833

00:48:51,480 --> 00:48:48,100

come to the last big shock you can

834

00:48:56,720 --> 00:48:51,490

imagine that these investigation of for

835

00:49:00,360 --> 00:48:56,730

example in the in investigating a

836

00:49:04,200 --> 00:49:00,370

specific extrasolar planetary systems we

837

00:49:07,320 --> 00:49:04,210

started with a so-called 47 you my

838

00:49:10,020 --> 00:49:07,330

system you know you ma was a miles so

839

00:49:13,620 --> 00:49:10,030

forty sevens brightest star in was a

840

00:49:17,940 --> 00:49:13,630

mayores which was discussed some years

841

00:49:20,610 --> 00:49:17,950

ago as a first system it has a little

842

00:49:21,860 --> 00:49:20,620

bit as similarly to the solar system

843

00:49:24,530 --> 00:49:21,870

because

844

00:49:27,980 --> 00:49:24,540

say discovered two giant planets a

845

00:49:32,210 --> 00:49:27,990

little bit outside comparable to to

846

00:49:34,790 --> 00:49:32,220

Jupiter ends at 2am and and so habitable

847

00:49:36,080 --> 00:49:34,800

zone was a little bit inside like in the

848

00:49:38,360 --> 00:49:36,090

solar system and therefore we

849

00:49:42,250 --> 00:49:38,370

investigated this and found out that

850

00:49:46,100 --> 00:49:42,260

water worlds are refilled and so nature

851
00:49:49,670 --> 00:49:46,110
didn't published our original paper but

852
00:49:51,860 --> 00:49:49,680
safe published an article about our of

853
00:49:55,100 --> 00:49:51,870
each neighborhood international journal

854
00:49:57,860 --> 00:49:55,110
of astrobiology and so there have been a

855
00:50:01,670 --> 00:49:57,870
lot of of media's that reported about

856
00:50:08,230 --> 00:50:01,680
says this was a top and this is a lower

857
00:50:10,820 --> 00:50:08,240
end sir yes I don't is a is a the most

858
00:50:14,030 --> 00:50:10,830
devious yellow dress and Germany likes

859
00:50:17,870 --> 00:50:14,040
the British son and they came to our

860
00:50:20,120 --> 00:50:17,880
Institute with wasn't in august 2003 I

861
00:50:23,180 --> 00:50:20,130
wasn't holiday this is my coworker

862
00:50:26,770 --> 00:50:23,190
thamma phut blow it built cycle came and

863
00:50:29,120 --> 00:50:26,780

took a photo of him and here our

864

00:50:31,190 --> 00:50:29,130

building of our Institute as a former

865

00:50:35,390 --> 00:50:31,200

astrophysics your thoughts comes Jose

866

00:50:38,900 --> 00:50:35,400

even had tillers go ahead and reported

867

00:50:41,470 --> 00:50:38,910

about self in the main point is there's

868

00:50:45,980 --> 00:50:41,480

a slogan village brings it to the point

869

00:50:49,400 --> 00:50:45,990

if say would have asked me to to write

870

00:50:52,100 --> 00:50:49,410

about it to talk about this possibility

871

00:50:55,310 --> 00:50:52,110

of the existence of the second girls in

872

00:50:58,520 --> 00:50:55,320

47 who say my yours in German posle

873

00:51:00,980 --> 00:50:58,530

there was a myosin was about big deal

874

00:51:03,010 --> 00:51:00,990

and I would have said there could be

875

00:51:05,840 --> 00:51:03,020

special conditions a harder sell

876

00:51:14,620 --> 00:51:05,850

conditions may be easier exist and so on

877

00:51:34,400 --> 00:51:18,650

this is my closing remarks and I think

878

00:51:37,720 --> 00:51:34,410

you very much for your attention a lot

879

00:51:40,640 --> 00:51:37,730

of your models seem to depend on having

880

00:51:43,460 --> 00:51:40,650

progressive continental growth built

881

00:51:47,180 --> 00:51:43,470

into an expanding continental area

882

00:51:50,150 --> 00:51:47,190

through time there's a substantial

883

00:51:52,790 --> 00:51:50,160

fraction of geoscientists who disagree

884

00:51:55,460 --> 00:51:52,800

with the conde model of that based on

885

00:51:57,800 --> 00:51:55,470

would argue that continental area on

886

00:52:02,870 --> 00:51:57,810

earth probably been pretty consistent

887

00:52:06,290 --> 00:52:02,880

since four billion years ago and also

888

00:52:08,510 --> 00:52:06,300

argue with the Schwartzman bottle for

889

00:52:11,390 --> 00:52:08,520

temperature evolution as worth arguing

890

00:52:14,810 --> 00:52:11,400

that's been roughly constant through

891

00:52:16,520 --> 00:52:14,820

time if you were to change the inputs

892

00:52:19,370 --> 00:52:16,530

into your model have a constant

893

00:52:20,900 --> 00:52:19,380

continental area relatively constant

894

00:52:29,450 --> 00:52:20,910

surface temperature how would that

895

00:52:34,280 --> 00:52:29,460

change things we use honey model the

896

00:52:37,940 --> 00:52:34,290

girls but we believed but was an

897

00:52:41,990 --> 00:52:37,950

extrasolar planetary system he usually

898

00:52:46,370 --> 00:52:42,000

used the model of constant continent ER

899

00:52:55,610 --> 00:52:46,380

but of course seminars for example if i

900

00:53:00,980 --> 00:52:55,620

go and i may go back here we always you

901
00:53:03,920 --> 00:53:00,990
can you can assume if the continent area

902
00:53:06,080 --> 00:53:03,930
is for example only 10,000 if we have a

903
00:53:09,380 --> 00:53:06,090
water world then we have this result was

904
00:53:11,990 --> 00:53:09,390
a blue we have no growing of continents

905
00:53:16,100 --> 00:53:12,000
in this because we be done no practical

906
00:53:18,200 --> 00:53:16,110
in nothing since extrasolar planetary

907
00:53:20,310 --> 00:53:18,210
system it but i was referring more to

908
00:53:22,860 --> 00:53:20,320
your terrestrial all

909
00:53:25,830 --> 00:53:22,870
the past and future evolution of the

910
00:53:28,680 --> 00:53:25,840
earth if you assume constant continental

911
00:53:47,310 --> 00:53:28,690
area in those other things change this

912
00:53:57,180 --> 00:53:47,320
is change publication I was you are why

913
00:53:59,280 --> 00:53:57,190

did I give ed but not one Jenny on the

914

00:54:01,500 --> 00:53:59,290

biological side I find that you have

915

00:54:04,560 --> 00:54:01,510

significantly underestimated the

916

00:54:06,360 --> 00:54:04,570

prokaryotic world and I see that in a

917

00:54:09,630 --> 00:54:06,370

couple of ways of the first part of your

918

00:54:12,150 --> 00:54:09,640

talk you have today's world being the

919

00:54:15,450 --> 00:54:12,160

carbon being tied up and only one third

920

00:54:18,120 --> 00:54:15,460

to the prokaryotic world whereas all the

921

00:54:21,150 --> 00:54:18,130

calculations I know about say majority

922

00:54:23,430 --> 00:54:21,160

of the biomass is prokaryotic today you

923

00:54:25,980 --> 00:54:23,440

also have a graph that shows the

924

00:54:27,890 --> 00:54:25,990

complete disappearance of prokaryotes at

925

00:54:31,590 --> 00:54:27,900

some point today or in the near future

926
00:54:33,360 --> 00:54:31,600
which doesn't make sense to me and so

927
00:54:35,880 --> 00:54:33,370
I'm wondering an under estimating a

928
00:54:38,100 --> 00:54:35,890
prokaryotic world how that carries over

929
00:54:39,900 --> 00:54:38,110
into the second part of your talk have

930
00:54:46,410 --> 00:54:39,910
you underestimated the number of

931
00:54:51,870 --> 00:54:46,420
habitable planets by coherence this is

932
00:54:55,200 --> 00:54:51,880
the first part of your question there is

933
00:54:58,200 --> 00:54:55,210
a number two days of biomass from from

934
00:55:01,170 --> 00:54:58,210
broken your tech pod is about one third

935
00:55:03,690 --> 00:55:01,180
I don't know if you speak about the deep

936
00:55:05,580 --> 00:55:03,700
biosphere I included that in the air if

937
00:55:07,710 --> 00:55:05,590
you include two deep biosphere of course

938
00:55:10,710 --> 00:55:07,720

but our our model is for the

939

00:55:12,930 --> 00:55:10,720

habitability it's a surface of cells so

940

00:55:14,850 --> 00:55:12,940

if you include a deep biosphere you are

941

00:55:21,300 --> 00:55:14,860

completing your attack you include the

942

00:55:24,050 --> 00:55:21,310

deep ocean only also not you know this

943

00:55:25,990 --> 00:55:24,060

is a is a box model the other ocean has

944

00:55:28,240 --> 00:55:26,000

well

945

00:55:33,250 --> 00:55:28,250

can you spot the same tumblers it's

946

00:55:35,290 --> 00:55:33,260

nothing especially resolved there's a

947

00:55:43,720 --> 00:55:35,300

fuji negative lifespan according to this

948

00:55:47,170 --> 00:55:43,730

is one part yes and i cannot say if of

949

00:55:50,290 --> 00:55:47,180

course the numbers will change if we

950

00:55:54,820 --> 00:55:50,300

make or more developed a model for the

951
00:55:58,750 --> 00:55:54,830
proprietary code but maybe answer is a

952
00:56:04,960 --> 00:55:58,760
case set that seasons a number of Ohio

953
00:56:07,630 --> 00:56:04,970
Jake well it's close up of us you know

954
00:56:09,490 --> 00:56:07,640
it hit our now all models a biosphere

955
00:56:12,960 --> 00:56:09,500
has only two limits namely the

956
00:56:16,840 --> 00:56:12,970
temperature tolerance window and

957
00:56:19,900 --> 00:56:16,850
secondly is a must be enough co2 wasn't

958
00:56:23,920 --> 00:56:19,910
so broke I oats are robust that they can

959
00:56:26,490 --> 00:56:23,930
live also at very high as a co2 contents

960
00:56:30,790 --> 00:56:26,500
the atmosphere in this model only is a

961
00:56:32,530 --> 00:56:30,800
complex work with this sensitive so I

962
00:56:36,390 --> 00:56:32,540
find that you've been conservative in

963
00:56:40,060 --> 00:56:36,400

your temperature range so if you if you

964

00:56:41,830 --> 00:56:40,070

reverse that position then I'm wondering

965

00:56:45,430 --> 00:56:41,840

how that translates to the rest of your

966

00:56:47,350 --> 00:56:45,440

conclusions if the prokaryotic the

967

00:56:51,790 --> 00:56:47,360

number of program carry otic world's

968

00:56:55,270 --> 00:56:51,800

potentially goes up this is the right

969

00:56:57,760 --> 00:56:55,280

direction because we think this ratio or

970

00:57:00,580 --> 00:56:57,770

from experience should be not risen like

971

00:57:02,800 --> 00:57:00,590

this is a little fun my drawing

972

00:57:10,749 --> 00:57:02,810

knowledge as was a to first quantitative

973

00:57:17,799 --> 00:57:14,329

and youth your temperature curve for the

974

00:57:19,910 --> 00:57:17,809

earth with us I'll talk I think you had

975

00:57:22,430 --> 00:57:19,920

between sort of two or three billion

976
00:57:24,849 --> 00:57:22,440
years you've got temperatures of 40 50

977
00:57:28,249 --> 00:57:24,859
60 degrees but there's evidence

978
00:57:32,630 --> 00:57:28,259
relations period because part vectors

979
00:57:34,970 --> 00:57:32,640
yes equation of 2.5 just question we

980
00:57:37,460 --> 00:57:34,980
have all the user it's a near photo it's

981
00:57:39,739 --> 00:57:37,470
all equally access no Porter's and so

982
00:57:42,759 --> 00:57:39,749
but but there's also evidence for

983
00:57:46,729 --> 00:57:42,769
snuggle as much about that this is a

984
00:57:49,870 --> 00:57:46,739
really is a very long skier temperatures

985
00:57:53,390 --> 00:57:49,880
that is called you know even here we had

986
00:57:55,489 --> 00:57:53,400
glaciations but this is not included in

987
00:57:57,890 --> 00:57:55,499
this model this is a geological

988
00:58:01,009 --> 00:57:57,900

background temperature but at least has

989

00:58:04,059 --> 00:58:01,019

evidence from cloud and louvers that at

990

00:58:07,729 --> 00:58:04,069

this time we had very very high

991

00:58:17,360 --> 00:58:07,739

temperatures in the ocean surface from

992

00:58:22,180 --> 00:58:19,660

they sent over Asia world models

993

00:58:24,590 --> 00:58:22,190

resistance of biosphere autopilot

994

00:58:25,910 --> 00:58:24,600

extends that have a polite and the

995

00:58:32,510 --> 00:58:25,920

biosphere is that true in all of your

996

00:58:35,210 --> 00:58:32,520

models as well yes we the XM discussion

997

00:58:42,970 --> 00:58:35,220

and for example here here we have a

998

00:58:46,280 --> 00:58:42,980

so-called gyan feedback because here

999

00:58:52,150 --> 00:58:46,290

when the when they are the conditions

1000

00:58:55,820 --> 00:58:52,160

for the existence of complex life-forms

1001
00:58:59,690 --> 00:58:55,830
hey they appeal and of course they take

1002
00:59:02,210 --> 00:58:59,700
out co2 from the atmosphere for making

1003
00:59:04,700 --> 00:59:02,220
sure biomass and when they take out co2

1004
00:59:08,570 --> 00:59:04,710
from the atmosphere they even have this

1005
00:59:11,930 --> 00:59:08,580
additional forcing of weathering this

1006
00:59:16,340 --> 00:59:11,940
bittersweet and so we have a negative

1007
00:59:18,380 --> 00:59:16,350
free kick good that makes us chump so

1008
00:59:23,420 --> 00:59:18,390
this is in ours ends it's a paper we

1009
00:59:29,240 --> 00:59:23,430
also discuss its kyanite but only here

1010
00:59:32,630 --> 00:59:29,250
at this point of the new discovery of

1011
00:59:35,720 --> 00:59:32,640
super Earths seems to extend a new cost

1012
00:59:37,430 --> 00:59:35,730
of planets that could be callable on the

1013
00:59:39,680 --> 00:59:37,440

other hand as i understand that there's

1014

00:59:43,490 --> 00:59:39,690

a group out of rice who is suggested

1015

00:59:46,160 --> 00:59:43,500

that anything over 1.1 mass earth will

1016

00:59:47,900 --> 00:59:46,170

have stagnant with tectonics such as

1017

00:59:50,660 --> 00:59:47,910

venus because you cannot do plate

1018

00:59:52,460 --> 00:59:50,670

tectonics so these seem to be mutually

1019

00:59:55,300 --> 00:59:52,470

contradictory and you thought about the

1020

00:59:58,700 --> 00:59:55,310

super Earths or the effective technology

1021

01:00:02,180 --> 00:59:58,710

yes and my doctor student christine of

1022

01:00:05,240 --> 01:00:02,190

goo na ma thesis about sis and using

1023

01:00:08,690 --> 01:00:05,250

using these evolution models and i know

1024

01:00:12,260 --> 01:00:08,700

is a popular matic but as i remember the

1025

01:00:17,180 --> 01:00:12,270

group from from our of valencia in haces

1026

01:00:19,940 --> 01:00:17,190

they proposed that suppose have a more

1027

01:00:22,340 --> 01:00:19,950

probability to have plate tectonics but

1028

01:00:26,090 --> 01:00:22,350

as a nasa was a massive publication that

1029

01:00:29,910 --> 01:00:26,100

says they have no protector we cannot

1030

01:00:32,789 --> 01:00:29,920

decide for in our model we assume as

1031

01:00:36,240 --> 01:00:32,799

who else is in earls like plans was a

1032

01:00:38,220 --> 01:00:36,250

chemistry of the earth with between one

1033

01:01:04,289 --> 01:00:38,230

and ten earth masses and whisper a

1034

01:01:08,910 --> 01:01:04,299

tektronix still very controversial that

1035

01:01:13,589 --> 01:01:08,920

he's very simple and if I may add a

1036

01:01:18,089 --> 01:01:13,599

further comment choices maybe you you

1037

01:01:22,520 --> 01:01:18,099

will read in a and a astronomy and

1038

01:01:28,670 --> 01:01:22,530

astrophysics our paper on the cleazor

1039

01:01:31,859 --> 01:01:28,680

581 system yeah you know one year ago

1040

01:01:33,870 --> 01:01:31,869

surf ranch group published a paper that

1041

01:01:38,309 --> 01:01:33,880

they found a second earth in this system

1042

01:01:40,260 --> 01:01:38,319

so cleazor see planet and we we

1043

01:01:42,750 --> 01:01:40,270

investigated the system really was our

1044

01:01:45,630 --> 01:01:42,760

model of subarus found that pleases see

1045

01:01:49,890 --> 01:01:45,640

is outside so habitable zone but please

1046

01:01:51,870 --> 01:01:49,900

deal the more far away could be at the

1047

01:01:56,099 --> 01:01:51,880

outer boundary of savage episode this

1048

01:02:06,390 --> 01:01:56,109

was also reported in in in nature yeah

1049

01:02:11,260 --> 01:02:08,500

using the diagram that's on the screen

1050

01:02:13,900 --> 01:02:11,270

now perhaps producers quickly explain

1051

01:02:17,830 --> 01:02:13,910

how you parameterize the prokaryote

1052

01:02:21,510 --> 01:02:17,840

reservoir sighs for example to be 3.5 25

1053

01:02:24,940 --> 01:02:21,520

living user no no not on that exactly

1054

01:02:29,340 --> 01:02:24,950

this is safe is a parameter research

1055

01:02:31,480 --> 01:02:29,350

Hong Kong yes we we have always the same

1056

01:02:34,320 --> 01:02:31,490

parameterization it changes at this time

1057

01:02:38,650 --> 01:02:34,330

this is a disadvantage because

1058

01:02:41,710 --> 01:02:38,660

biologists told me use a c4 plants but

1059

01:02:44,310 --> 01:02:41,720

in future we may have c5 plants that

1060

01:02:46,360 --> 01:02:44,320

have for example no er limit

1061

01:02:49,450 --> 01:02:46,370

photosynthesis which is much lower than

1062

01:02:53,880 --> 01:02:49,460

send our but it is not so easy to

1063

01:02:57,220 --> 01:02:53,890

predict evolution and says are for our

1064

01:02:59,920 --> 01:02:57,230

model has always follow the whole time