



1  
00:00:00,790 --> 00:00:07,320

[Music]

2  
00:00:11,129 --> 00:00:09,410

[Applause]

3  
00:00:12,660 --> 00:00:11,139

thanks Morgan

4  
00:00:15,270 --> 00:00:12,670

it's great to be here and it's great to

5  
00:00:16,800 --> 00:00:15,280

follow Marc's talk which I introduced

6  
00:00:17,880 --> 00:00:16,810

some geophysical concepts for things

7  
00:00:19,769 --> 00:00:17,890

that we still have yet to figure out

8  
00:00:21,660 --> 00:00:19,779

about Enceladus so what I'm going to

9  
00:00:24,120 --> 00:00:21,670

tell you about is a work-in-progress is

10  
00:00:26,099 --> 00:00:24,130

a JPL supported study it's also

11  
00:00:27,659 --> 00:00:26,109

leveraging support from the NASA

12  
00:00:31,259 --> 00:00:27,669

Astrobiology Institute namely the icy

13  
00:00:32,609 --> 00:00:31,269

worlds program and the idea is to we'll

14

00:00:34,650 --> 00:00:32,619

get distributed geophysical measurements

15

00:00:37,319 --> 00:00:34,660

either combination of orbiter and Lander

16

00:00:38,850 --> 00:00:37,329

or network of Landers to answer

17

00:00:41,910 --> 00:00:38,860

questions about being habitability of

18

00:00:42,959 --> 00:00:41,920

Enceladus so I'd like to not name all of

19

00:00:45,590 --> 00:00:42,969

my authors but just emphasize that

20

00:00:48,540 --> 00:00:45,600

they're people from all over the US and

21

00:00:51,450 --> 00:00:48,550

and also in France and the Czech

22

00:00:55,110 --> 00:00:51,460

Republic and I'll mention work by these

23

00:00:55,979 --> 00:00:55,120

folks so study goals again assess needed

24

00:00:58,229 --> 00:00:55,989

geophysical measurements for

25

00:01:01,740 --> 00:00:58,239

habitability as part of future searches

26

00:01:04,140 --> 00:01:01,750

for life on Enceladus and yeah so to

27

00:01:05,850 --> 00:01:04,150

summarize yeah the orbital either an

28

00:01:07,170 --> 00:01:05,860

orbital only so single or multiple

29

00:01:09,450 --> 00:01:07,180

spacecraft is would that be sufficient

30

00:01:12,569 --> 00:01:09,460

to enter the main geophysical questions

31

00:01:14,399 --> 00:01:12,579

would we need a if we land would have

32

00:01:16,469 --> 00:01:14,409

single Lander be enough would we need a

33

00:01:18,330 --> 00:01:16,479

network or perhaps some cooperation

34

00:01:20,429 --> 00:01:18,340

between them so these are just examples

35

00:01:22,200 --> 00:01:20,439

of concepts that have been studied this

36

00:01:25,170 --> 00:01:22,210

one was for Europa the graphic was

37

00:01:27,539 --> 00:01:25,180

convenient just suffice it to say there

38

00:01:30,210 --> 00:01:27,549

are ideas for Landers for in Celicas as

39

00:01:34,469 --> 00:01:30,220

well I'll also point out this is a

40

00:01:35,639 --> 00:01:34,479

modified graphic from a NASA artwork

41

00:01:38,370 --> 00:01:35,649

that was part of a press release I

42

00:01:40,380 --> 00:01:38,380

modified it to emphasize that we now

43

00:01:42,450 --> 00:01:40,390

understand that the ice is thinner at

44

00:01:43,889 --> 00:01:42,460

the poles of Enceladus so we'd like to

45

00:01:45,539 --> 00:01:43,899

understand why that is it's just one of

46

00:01:46,980 --> 00:01:45,549

the questions we want to understand so

47

00:01:48,149 --> 00:01:46,990

let me just try to motivate the

48

00:01:49,469 --> 00:01:48,159

connection between geophysics and

49

00:01:51,090 --> 00:01:49,479

habitability a little bit this isn't my

50

00:01:55,560 --> 00:01:51,100

real my main soapbox in the last few

51  
00:01:57,240 --> 00:01:55,570  
years so here's a nice figure from a

52  
00:01:59,249 --> 00:01:57,250  
work that's been prepped by one of our

53  
00:02:02,010 --> 00:01:59,259  
team members and a Lobo a grad student

54  
00:02:04,020 --> 00:02:02,020  
at Caltech working with Andy Thompson so

55  
00:02:06,569 --> 00:02:04,030  
the insight here because of this ice

56  
00:02:08,249 --> 00:02:06,579  
thickness variation infer from Cassini

57  
00:02:10,350 --> 00:02:08,259  
measurements Chadha as part of our group

58  
00:02:12,240 --> 00:02:10,360  
as well the work by Hemingway agrees

59  
00:02:15,900 --> 00:02:12,250  
well it has a little more interpretation

60  
00:02:18,570 --> 00:02:15,910  
of the gravity data so this implies a

61  
00:02:19,619 --> 00:02:18,580  
lateral transport because where the ice

62  
00:02:21,780 --> 00:02:19,629  
is thin

63  
00:02:23,160 --> 00:02:21,790

you should have melting and that should

64

00:02:27,030 --> 00:02:23,170

lead to refreezing

65

00:02:28,739 --> 00:02:27,040

and where the ice is thicker and so yeah

66

00:02:31,500 --> 00:02:28,749

you have meltwater traveling along the

67

00:02:33,929 --> 00:02:31,510

ice so if there's if the ocean is salty

68

00:02:36,449 --> 00:02:33,939

at all the lateral transport implies an

69

00:02:37,800 --> 00:02:36,459

overturning convection and so we want to

70

00:02:39,929 --> 00:02:37,810

understand how that works

71

00:02:41,640 --> 00:02:39,939

and how that factors into any geothermal

72

00:02:42,899 --> 00:02:41,650

transport namely if there are

73

00:02:43,440 --> 00:02:42,909

hydrothermal plumes at the base of

74

00:02:46,550 --> 00:02:43,450

Enceladus

75

00:02:48,509 --> 00:02:46,560

or as scales Roble has studied

76

00:02:52,110 --> 00:02:48,519

distributed sorry

77

00:02:53,009 --> 00:02:52,120

throughout the the body of Enceladus so

78

00:02:55,399 --> 00:02:53,019

that's that's one thing that we're

79

00:02:57,149 --> 00:02:55,409

working on that couples in with

80

00:03:01,589 --> 00:02:57,159

determine the transport properties the

81

00:03:03,089 --> 00:03:01,599

ocean couples in with more general

82

00:03:05,550 --> 00:03:03,099

geophysical work including working with

83

00:03:07,740 --> 00:03:05,560

Gail Schilling and Gabriel Toby the kind

84

00:03:10,110 --> 00:03:07,750

of thing that was nicely explored in

85

00:03:12,449 --> 00:03:10,120

this 1d model by Melvin and pre-amp

86

00:03:14,879 --> 00:03:12,459

realloc and now is been worked by

87

00:03:17,959 --> 00:03:14,889

postdoc working with me Mohit Mel

88

00:03:20,069 --> 00:03:17,969

juanita swanee also point out that

89

00:03:22,289 --> 00:03:20,079

there's a nice talk tomorrow about be

90

00:03:24,390 --> 00:03:22,299

organics in Enceladus in the prebiotic

91

00:03:27,089 --> 00:03:24,400

chemistry session at 11 o'clock by Frank

92

00:03:29,580 --> 00:03:27,099

host Berg ok so this is the background

93

00:03:32,909 --> 00:03:29,590

for our study so what we've done this is

94

00:03:35,429 --> 00:03:32,919

sort of a small science definition team

95

00:03:36,869 --> 00:03:35,439

kind of study so we tried to identify

96

00:03:39,530 --> 00:03:36,879

all of the questions that you would want

97

00:03:41,969 --> 00:03:39,540

to look at and in order to connect

98

00:03:43,159 --> 00:03:41,979

geophysical measurements habitability so

99

00:03:45,689 --> 00:03:43,169

just running through them very quickly

100

00:03:47,939 --> 00:03:45,699

what's the distribution distribution of

101  
00:03:49,080 --> 00:03:47,949  
tidal heat what's why is there a

102  
00:03:52,199 --> 00:03:49,090  
difference between the North Pole in the

103  
00:03:53,849 --> 00:03:52,209  
South Pole where is the high temperature

104  
00:03:54,929 --> 00:03:53,859  
water rock interaction happening we do

105  
00:03:56,729 --> 00:03:54,939  
have evidence for high temperature water

106  
00:03:57,839 --> 00:03:56,739  
rock interaction is it all at the South

107  
00:03:59,219 --> 00:03:57,849  
Pole

108  
00:04:01,349 --> 00:03:59,229  
and then what's the mass exchange as I

109  
00:04:04,969 --> 00:04:01,359  
mentioned earlier where the rate of

110  
00:04:08,369 --> 00:04:04,979  
delivery of oxidants to the ocean and

111  
00:04:09,390 --> 00:04:08,379  
also how does the ice fraction Nate the

112  
00:04:12,569 --> 00:04:09,400  
materials that are coming out of the

113  
00:04:14,670 --> 00:04:12,579

plume and lastly what is the nature of

114

00:04:16,709 --> 00:04:14,680

the ocean transport so we can glibly

115

00:04:19,409 --> 00:04:16,719

summarize those with these convenient

116

00:04:21,089 --> 00:04:19,419

markers at the bottom that correspond to

117

00:04:22,709 --> 00:04:21,099

the numbers and so I'll refer to those

118

00:04:24,210 --> 00:04:22,719

as I run through some measurements that

119

00:04:25,950 --> 00:04:24,220

would one one would want to make

120

00:04:27,780 --> 00:04:25,960

so I can point out that Europa clipper

121

00:04:28,980 --> 00:04:27,790

has an ice penetrating radar I think

122

00:04:31,110 --> 00:04:28,990

this is going to revolutionize our

123

00:04:32,490 --> 00:04:31,120

understanding of ice geo dynamics it

124

00:04:34,500 --> 00:04:32,500

would be great to take something like

125

00:04:37,050 --> 00:04:34,510

that to Enceladus we could think of

126  
00:04:38,640 --> 00:04:37,060  
stepping up that and if we have

127  
00:04:41,250 --> 00:04:38,650  
crossover measurements from an orbiter

128  
00:04:43,200 --> 00:04:41,260  
we could actually do synthetic aperture

129  
00:04:46,440 --> 00:04:43,210  
radar mapping and that would allow us to

130  
00:04:47,910 --> 00:04:46,450  
see where motion is actually happening

131  
00:04:51,060 --> 00:04:47,920  
so there are different methods of doing

132  
00:04:53,760 --> 00:04:51,070  
that there's traditional radar method

133  
00:04:55,560 --> 00:04:53,770  
methods there's also a light detection

134  
00:04:57,150 --> 00:04:55,570  
and ranging which I expect would be

135  
00:04:59,520 --> 00:04:57,160  
lower energy but don't quote me on that

136  
00:05:01,110 --> 00:04:59,530  
and those have corresponding levels of

137  
00:05:03,420 --> 00:05:01,120  
precision which we can map in our study

138  
00:05:07,590 --> 00:05:03,430

and that would be something on our

139

00:05:10,020 --> 00:05:07,600

orbiter mm-hmm similarly we want to

140

00:05:12,450 --> 00:05:10,030

improve on the thermal measurements that

141

00:05:14,610 --> 00:05:12,460

Cassini did so these are examples of

142

00:05:16,650 --> 00:05:14,620

measurements from from Cassini across

143

00:05:20,370 --> 00:05:16,660

the tiger stripes at one particular

144

00:05:22,410 --> 00:05:20,380

tiger stripe here and from a few in his

145

00:05:25,170 --> 00:05:22,420

larger image and so we want to improve

146

00:05:28,050 --> 00:05:25,180

on that hopefully the elf study that I

147

00:05:29,880 --> 00:05:28,060

referred to earlier states a range of

148

00:05:32,510 --> 00:05:29,890

spatial resolution sensitivity that we

149

00:05:35,250 --> 00:05:32,520

would want for that kind of measurement

150

00:05:36,870 --> 00:05:35,260

so electromagnetic sounding this is

151  
00:05:39,600 --> 00:05:36,880  
going to be a crucial measurement for

152  
00:05:41,460 --> 00:05:39,610  
the Europa clipper namely by taking

153  
00:05:44,310 --> 00:05:41,470  
advantage of the tilted dipole magnetic

154  
00:05:47,400 --> 00:05:44,320  
field of Jupiter to look at the induced

155  
00:05:49,100 --> 00:05:47,410  
response of Europa Saturn's magnetic

156  
00:05:51,360 --> 00:05:49,110  
field is somewhat inconveniently

157  
00:05:52,890 --> 00:05:51,370  
directly aligned with its rotation and

158  
00:05:56,070 --> 00:05:52,900  
so that is not something that we can

159  
00:05:59,010 --> 00:05:56,080  
utilize however the the orbit of

160  
00:06:01,650 --> 00:05:59,020  
Enceladus as Mark explored it's somewhat

161  
00:06:04,080 --> 00:06:01,660  
eccentric because that provides a way to

162  
00:06:06,120 --> 00:06:04,090  
measure variations also we might use

163  
00:06:08,280 --> 00:06:06,130

external oscillations in the field

164

00:06:09,990 --> 00:06:08,290

itself so that is although the of the

165

00:06:12,270 --> 00:06:10,000

Saturn's field is not tilted and so it's

166

00:06:13,740 --> 00:06:12,280

not varying due to its rotation it might

167

00:06:17,630 --> 00:06:13,750

vary intrinsically just because of

168

00:06:20,040 --> 00:06:17,640

variations within Saturn itself and

169

00:06:22,800 --> 00:06:20,050

let's see so that's something we could

170

00:06:24,420 --> 00:06:22,810

employ on a lander even although a

171

00:06:27,360 --> 00:06:24,430

single Lander would probably only be

172

00:06:29,210 --> 00:06:27,370

able to get the to infer the thickness

173

00:06:31,380 --> 00:06:29,220

of the ocean and the salinity not be

174

00:06:34,500 --> 00:06:31,390

variation in thickness or changes in

175

00:06:36,480 --> 00:06:34,510

salinity if any exists okay so we've

176

00:06:37,129 --> 00:06:36,490

done a little bit more work on gravity

177

00:06:38,809 --> 00:06:37,139

the

178

00:06:40,520 --> 00:06:38,819

with our team members who are in Prague

179

00:06:43,730 --> 00:06:40,530

also working with our team members in

180

00:06:44,869 --> 00:06:43,740

France and so that characters is a lead

181

00:06:46,640 --> 00:06:44,879

author on some of those Murray Ben

182

00:06:49,459 --> 00:06:46,650

koba's and others they have a few papers

183

00:06:51,080 --> 00:06:49,469

recently on the distribution of tides

184

00:06:52,279 --> 00:06:51,090

and Enceladus including taking advantage

185

00:06:55,909 --> 00:06:52,289

of our knowledge of the topography of

186

00:06:58,249 --> 00:06:55,919

Enceladus as ice so here I'm showing two

187

00:07:01,640 --> 00:06:58,259

different model runs that they did for

188

00:07:04,189 --> 00:07:01,650

us one with with no deformation in the

189

00:07:06,170 --> 00:07:04,199

in the rocky part of Enceladus and

190

00:07:09,350 --> 00:07:06,180

another accounting for that deformation

191

00:07:10,369 --> 00:07:09,360

you can see they're different and and

192

00:07:12,890 --> 00:07:10,379

this is also accounting for the

193

00:07:14,360 --> 00:07:12,900

topography at the at the South Pole so

194

00:07:16,429 --> 00:07:14,370

these are the kinds of variations in

195

00:07:18,230 --> 00:07:16,439

gravity that we could measure with an

196

00:07:21,529 --> 00:07:18,240

orbiter the orbiter would have to go

197

00:07:23,179 --> 00:07:21,539

very slow so less than 2.2 kilometers

198

00:07:24,860 --> 00:07:23,189

per second at an altitude of hundred

199

00:07:25,999 --> 00:07:24,870

kilometers and so that's not something

200

00:07:27,339 --> 00:07:26,009

you could achieve with the multiple

201  
00:07:29,869 --> 00:07:27,349  
flyby mission so you can't envision

202  
00:07:31,999 --> 00:07:29,879  
orbiting Saturn and flying buy and sell

203  
00:07:33,950 --> 00:07:32,009  
it it's like for example like we're

204  
00:07:36,980 --> 00:07:33,960  
doing with your OPA clipper around

205  
00:07:38,480 --> 00:07:36,990  
Jupiter not around Saturn so you could

206  
00:07:40,100 --> 00:07:38,490  
also do gravity from a lander it might

207  
00:07:43,429 --> 00:07:40,110  
be it would be beneficial to have

208  
00:07:44,719 --> 00:07:43,439  
multiple vendors in that case another

209  
00:07:48,709 --> 00:07:44,729  
thing you can do that's related to

210  
00:07:49,459 --> 00:07:48,719  
gravity from the same model runs that I

211  
00:07:51,409 --> 00:07:49,469  
showed you previously

212  
00:07:55,219 --> 00:07:51,419  
you can also compute how much the

213  
00:07:57,139 --> 00:07:55,229

surface of evidence' lattice is flexing

214

00:07:59,209 --> 00:07:57,149

it's tilting you would sense that if you

215

00:08:00,379 --> 00:07:59,219

were on the surface as a slight tilt if

216

00:08:01,790 --> 00:08:00,389

you looked up at the stars you would see

217

00:08:04,579 --> 00:08:01,800

they're moving a little bit that motion

218

00:08:06,439 --> 00:08:04,589

that turns out is on the order of 2

219

00:08:07,369 --> 00:08:06,449

micro radians so it's very small that's

220

00:08:09,079 --> 00:08:07,379

the kind of thing you wouldn't be able

221

00:08:10,969 --> 00:08:09,089

to see if you were orbiting Enceladus

222

00:08:12,139 --> 00:08:10,979

but you would be able to sense that with

223

00:08:13,869 --> 00:08:12,149

a dedicated instrument or even a

224

00:08:17,689 --> 00:08:13,879

seismometer on the surface of Enceladus

225

00:08:19,219 --> 00:08:17,699

so moving on to seismology we've done a

226

00:08:21,679 --> 00:08:19,229

lot of work on this thanks to a previous

227

00:08:24,170 --> 00:08:21,689

study that we went through for the last

228

00:08:25,429 --> 00:08:24,180

three years previous three years so I

229

00:08:26,749 --> 00:08:25,439

will assert that this is the best

230

00:08:28,969 --> 00:08:26,759

technique for resolving the interior

231

00:08:32,329 --> 00:08:28,979

structure is the only way you're going

232

00:08:34,880 --> 00:08:32,339

to sense the detail composition of the

233

00:08:37,069 --> 00:08:34,890

deeper rocky interior I think in a

234

00:08:38,600 --> 00:08:37,079

categorical way and I can I can

235

00:08:41,180 --> 00:08:38,610

emphasize that you would have that

236

00:08:44,149 --> 00:08:41,190

information even more supported if you

237

00:08:46,120 --> 00:08:44,159

were able to separate your seismic

238

00:08:50,470 --> 00:08:46,130

interpretation

239

00:08:53,499 --> 00:08:50,480

based on gravity measurements and a

240

00:08:55,480 --> 00:08:53,509

medic field measurements so a single

241

00:08:58,509 --> 00:08:55,490

seismometer as is being employed on the

242

00:09:00,040 --> 00:08:58,519

insight mission on Europa could detect

243

00:09:03,160 --> 00:09:00,050

signals generated anywhere within

244

00:09:05,590 --> 00:09:03,170

Enceladus there's a Mars I said in

245

00:09:07,629 --> 00:09:05,600

Soledad Europa okay too many too many

246

00:09:08,439 --> 00:09:07,639

planets just to talk about pardon me

247

00:09:10,420 --> 00:09:08,449

pardon me

248

00:09:12,400 --> 00:09:10,430

now you don't usually say Mars that

249

00:09:15,120 --> 00:09:12,410

often which is it which is a drawback of

250

00:09:18,519 --> 00:09:15,130

mine it's not another criticism of Mars

251  
00:09:20,290 --> 00:09:18,529  
so right and so since we know there's

252  
00:09:21,850 --> 00:09:20,300  
observed plume activity that itself is a

253  
00:09:24,009 --> 00:09:21,860  
seismic source that we could utilize and

254  
00:09:26,259 --> 00:09:24,019  
there are analogies in the form of

255  
00:09:28,960 --> 00:09:26,269  
geysers on earth and volcanic tremor

256  
00:09:32,170 --> 00:09:28,970  
that might allow us to predict what

257  
00:09:33,850 --> 00:09:32,180  
those would look like seismically of

258  
00:09:35,170 --> 00:09:33,860  
course multiple seismometers could

259  
00:09:37,509 --> 00:09:35,180  
reveal the mechanics of those fissures

260  
00:09:39,129 --> 00:09:37,519  
or in general be much more helpful for

261  
00:09:40,930 --> 00:09:39,139  
mapping activity inside of Enceladus

262  
00:09:43,180 --> 00:09:40,940  
I should explain this complicated graph

263  
00:09:45,280 --> 00:09:43,190

if you've taken an introductory

264

00:09:47,590 --> 00:09:45,290

seismology class you would see something

265

00:09:49,180 --> 00:09:47,600

like this extending over an hour rather

266

00:09:50,590 --> 00:09:49,190

than 300 seconds I'm sorry the top is

267

00:09:51,999 --> 00:09:50,600

cut off it's just showing the

268

00:09:54,100 --> 00:09:52,009

propagation of different waves the

269

00:09:56,290 --> 00:09:54,110

transverse the the radial and the

270

00:09:58,120 --> 00:09:56,300

azimuthal components of the waves are

271

00:09:59,889 --> 00:09:58,130

the different colors over a period of

272

00:10:01,780 --> 00:09:59,899

time and as a function of distance all

273

00:10:04,240 --> 00:10:01,790

the way from the source to halfway

274

00:10:05,379 --> 00:10:04,250

around Enceladus so it's just it's just

275

00:10:07,179 --> 00:10:05,389

showing that you can see reflections

276

00:10:08,559 --> 00:10:07,189

these are these different kind of

277

00:10:10,030 --> 00:10:08,569

scattered features over here on the

278

00:10:11,889 --> 00:10:10,040

right are reflections from different

279

00:10:13,329 --> 00:10:11,899

boundaries including the bottom of the

280

00:10:16,179 --> 00:10:13,339

ice shell and the bottom of the ocean

281

00:10:18,220 --> 00:10:16,189

and so we can do this kind of modeling

282

00:10:20,620 --> 00:10:18,230

in the forward modeling fashion thanks

283

00:10:23,230 --> 00:10:20,630

to modern computational technology in

284

00:10:25,749 --> 00:10:23,240

fact based on radial structure models

285

00:10:28,269 --> 00:10:25,759

that I've come up with combined with

286

00:10:30,340 --> 00:10:28,279

that topography and ice thickness that I

287

00:10:32,170 --> 00:10:30,350

mentioned earlier we can create detailed

288

00:10:33,550 --> 00:10:32,180

models Enceladus either either asserting

289

00:10:35,530 --> 00:10:33,560

radial symmetry or taking into account

290

00:10:37,990 --> 00:10:35,540

the variations and then we can do those

291

00:10:40,329 --> 00:10:38,000

full wave form models so we've another

292

00:10:43,059 --> 00:10:40,339

postdoc working with us at JPL using

293

00:10:45,160 --> 00:10:43,069

salvus a program that's being developed

294

00:10:46,420 --> 00:10:45,170

so I'll show you an animation this is

295

00:10:48,370 --> 00:10:46,430

this this graphic is showing

296

00:10:51,220 --> 00:10:48,380

specifically the case where you don't

297

00:10:52,840 --> 00:10:51,230

have where you have you're not ready

298

00:10:54,579 --> 00:10:52,850

you're not sterically symmetric so the

299

00:10:56,110 --> 00:10:54,589

ice shells varying in thickness and also

300

00:10:57,400 --> 00:10:56,120

in topography

301

00:10:59,380 --> 00:10:57,410

so in the movie that you'll see on the

302

00:11:03,940 --> 00:10:59,390

left the comparison of the spherically

303

00:11:05,850 --> 00:11:03,950

symmetric case so you can see the source

304

00:11:08,890 --> 00:11:05,860

from the South Pole just read just

305

00:11:12,220 --> 00:11:08,900

reverberating to the North Pole and back

306

00:11:15,040 --> 00:11:12,230

and this is accounting for propagating

307

00:11:16,570 --> 00:11:15,050

modes in the in the deeper interior as

308

00:11:17,470 --> 00:11:16,580

well it's much more complicated and

309

00:11:19,510 --> 00:11:17,480

chaotic

310

00:11:21,400 --> 00:11:19,520

if you account for the actual features

311

00:11:23,500 --> 00:11:21,410

of Enceladus so there's more work to do

312

00:11:26,019 --> 00:11:23,510

and we're doing that work so just

313

00:11:27,160 --> 00:11:26,029

wrapping it up then a single orbiter

314

00:11:28,570 --> 00:11:27,170

could certainly advance our

315

00:11:30,400 --> 00:11:28,580

understanding themselves interior

316

00:11:33,190 --> 00:11:30,410

including the heat and composition and

317

00:11:35,890 --> 00:11:33,200

the workings of the ice turns out you

318

00:11:37,630 --> 00:11:35,900

that the the some of the requirements

319

00:11:39,730 --> 00:11:37,640

for those gravity measurements would

320

00:11:42,880 --> 00:11:39,740

would only be achieved if you had some

321

00:11:45,160 --> 00:11:42,890

kind of surface device as well it could

322

00:11:46,630 --> 00:11:45,170

be just a mirror but this is this is

323

00:11:49,060 --> 00:11:46,640

pointing to the benefits of having a

324

00:11:51,880 --> 00:11:49,070

combined lander orbiter mission of

325

00:11:53,769 --> 00:11:51,890

course a network of Landers would be

326

00:11:54,910 --> 00:11:53,779

helpful you can a single Lander give us

327

00:11:57,790 --> 00:11:54,920

some really interesting information I

328

00:12:00,760 --> 00:11:57,800

think the best outcome would be to

329

00:12:02,650 --> 00:12:00,770

combine all of those things and in a

330

00:12:04,720 --> 00:12:02,660

future version its presentation and the

331

00:12:07,060 --> 00:12:04,730

paper that will follow I look forward to

332

00:12:09,040 --> 00:12:07,070

sharing more rigorous studies of the

333

00:12:10,540 --> 00:12:09,050

cost and other things that the factor

334

00:12:14,930 --> 00:12:10,550

and prioritizing among those so thank