
Dunde Ice Cap
ueicceya Ice Cap

1
00:00:40,150 --> 00:00:37,210
good afternoon and welcome to the

2
00:00:42,040 --> 00:00:40,160
administrators seminar series we're here

3
00:00:44,980 --> 00:00:42,050
once again to discuss the nation's

4
00:00:46,810 --> 00:00:44,990
future in space this is the fourth in a

5
00:00:48,910 --> 00:00:46,820
series of dialogues that looks at

6
00:00:52,600 --> 00:00:48,920
different aspects of what might comprise

7
00:00:54,340 --> 00:00:52,610
a driving goal for the next era a goal

8
00:00:56,020 --> 00:00:54,350
that's fundamentally character and

9
00:00:59,590 --> 00:00:56,030
that's important to the public that

10
00:01:02,620 --> 00:00:59,600
supports the space program Martin Luther

11
00:01:04,870 --> 00:01:02,630
King said as marvelous as the stars is

12
00:01:07,780 --> 00:01:04,880
the mind of the person who studies them

13
00:01:11,260 --> 00:01:07,790

and so when we began this series in

14
00:01:14,050 --> 00:01:11,270
January we started with life what is

15
00:01:16,900 --> 00:01:14,060
life mean how would we recognize it

16
00:01:19,749 --> 00:01:16,910
elsewhere either in our own solar system

17
00:01:23,200 --> 00:01:19,759
or on another earth orbiting a distant

18
00:01:26,830 --> 00:01:23,210
Sun the mind of the person who studies

19
00:01:29,260 --> 00:01:26,840
the Stars created cosmology by virtue of

20
00:01:32,109 --> 00:01:29,270
this activity we put ourselves squarely

21
00:01:36,249 --> 00:01:32,119
at the center of the universe looking

22
00:01:39,040 --> 00:01:36,259
outwards this theme life and it's self

23
00:01:41,469 --> 00:01:39,050
conscious exploration of itself in the

24
00:01:45,340 --> 00:01:41,479
cosmos form the basis of our first three

25
00:01:48,520 --> 00:01:45,350
seminars today's seminar is called new

26
00:01:50,800 --> 00:01:48,530
frontiers and climate research the

27
00:01:52,990 --> 00:01:50,810
refrain from lynn margulis the speaker

28
00:01:56,380 --> 00:01:53,000
at our first seminar runs through

29
00:01:59,800 --> 00:01:56,390
today's to life is a planetary

30
00:02:01,660 --> 00:01:59,810
phenomenon that she said the images we

31
00:02:04,240 --> 00:02:01,670
have gotten back from our shuttle

32
00:02:07,320 --> 00:02:04,250
missions show clearly the climate and

33
00:02:10,930 --> 00:02:07,330
its change are a planetary phenomenon

34
00:02:13,090 --> 00:02:10,940
life thrived in abundance without self

35
00:02:16,540 --> 00:02:13,100
awareness for perhaps three and a half

36
00:02:18,610 --> 00:02:16,550
billion years yet nor much briefer

37
00:02:22,270 --> 00:02:18,620
history on the planet we have

38
00:02:24,610 --> 00:02:22,280

transformed it what is the impact of the

39
00:02:27,309 --> 00:02:24,620
climate on climate of our own actions

40
00:02:30,070 --> 00:02:27,319
and what is the interplay of our doings

41
00:02:31,870 --> 00:02:30,080
and that of nature's how do all the

42
00:02:36,449 --> 00:02:31,880
different aspects of climate research

43
00:02:38,949 --> 00:02:36,459
fit into one overall planetary picture

44
00:02:41,320 --> 00:02:38,959
understanding this has motivated a u.s.

45
00:02:42,790 --> 00:02:41,330
Global Change Program and NASA's part of

46
00:02:45,370 --> 00:02:42,800
it which is called mission to Planet

47
00:02:47,140 --> 00:02:45,380
Earth today we're going to hear how

48
00:02:49,420 --> 00:02:47,150
science and space contribu

49
00:02:53,020 --> 00:02:49,430
to this mission and our distinguished

50
00:02:56,289 --> 00:02:53,030
speakers dr. Ellen Mosley Thompson and

51
00:02:58,449 --> 00:02:56,299
dr. Michael McElroy will address the

52
00:03:01,050 --> 00:02:58,459
question of what should be our long-term

53
00:03:03,360 --> 00:03:01,060
vision for monitoring the planet and

54
00:03:05,619 --> 00:03:03,370
communicating this information widely

55
00:03:08,440 --> 00:03:05,629
I'd first like to bring up the NASA

56
00:03:10,420 --> 00:03:08,450
Administrator Mr Dan Goldin whose vision

57
00:03:12,460 --> 00:03:10,430
shaped these seminars and whose

58
00:03:27,390 --> 00:03:12,470
leadership propels us to consider a

59
00:03:33,729 --> 00:03:31,229
was recently in a set of discussions

60
00:03:37,750 --> 00:03:33,739
with some of the people from Robert

61
00:03:42,699 --> 00:03:37,760
Mondavi wineries and they have a problem

62
00:03:44,500 --> 00:03:42,709
it's called philosophy that comes around

63
00:03:49,539 --> 00:03:44,510

every hundred years or so and it wiped

64
00:03:53,229 --> 00:03:49,549
out the grapes in France and it's now in

65
00:03:55,089 --> 00:03:53,239
the process of beginning to destroy some

66
00:03:58,479 --> 00:03:55,099
of the grape vines in Northern

67
00:04:01,330 --> 00:03:58,489
California it's very interesting about

68
00:04:04,240 --> 00:04:01,340
falaka when you're on the ground you

69
00:04:06,369 --> 00:04:04,250
don't see it you don't know that it's

70
00:04:09,129 --> 00:04:06,379
beginning to destroy the plants down in

71
00:04:12,129 --> 00:04:09,139
its root system but from the height of

72
00:04:14,740 --> 00:04:12,139
space you could look down with a

73
00:04:18,159 --> 00:04:14,750
hyperspectral device and you could

74
00:04:21,759 --> 00:04:18,169
actually see the stress on the grape

75
00:04:24,969 --> 00:04:21,769
vines from the philosopher so what this

76
00:04:26,800 --> 00:04:24,979
tells us is when you're close you can't

77
00:04:30,399 --> 00:04:26,810
necessarily they say you can't see the

78
00:04:32,589 --> 00:04:30,409
forest from the trees space gives us an

79
00:04:35,409 --> 00:04:32,599
ability to holistically look down on our

80
00:04:38,140 --> 00:04:35,419
own planet and get a sense not just

81
00:04:40,480 --> 00:04:38,150
about what's happening in this spot oh

82
00:04:43,360 --> 00:04:40,490
that's pot we get a broad holistic view

83
00:04:48,040 --> 00:04:43,370
of our own planet and it touches

84
00:04:51,159 --> 00:04:48,050
everybody's life and as we have 5.5

85
00:04:54,460 --> 00:04:51,169
billion strong on this planet preparing

86
00:04:57,430 --> 00:04:54,470
for as many as 10 billion perhaps in

87
00:04:59,500 --> 00:04:57,440
30-40 years from now it's very very

88
00:05:00,200 --> 00:04:59,510

important that we understand the forces

89
00:05:02,900 --> 00:05:00,210
of nature

90
00:05:06,110 --> 00:05:02,910
and we understand the forces of the

91
00:05:09,080 --> 00:05:06,120
human species and right now most of the

92
00:05:11,270 --> 00:05:09,090
debate that takes place with regards to

93
00:05:13,550 --> 00:05:11,280
our environment is based on passion and

94
00:05:16,040 --> 00:05:13,560
emotion and who could print the most who

95
00:05:18,409 --> 00:05:16,050
could get the best press bite what we'd

96
00:05:20,900 --> 00:05:18,419
like to do is have rational decisions

97
00:05:22,640 --> 00:05:20,910
about our environment about our own

98
00:05:25,580 --> 00:05:22,650
planet and how we manage those resources

99
00:05:29,900 --> 00:05:25,590
and that could only come with a holistic

100
00:05:32,870 --> 00:05:29,910
view so we are set out on a course and

101
00:05:34,460 --> 00:05:32,880
we only see maybe five or ten years out

102
00:05:38,150 --> 00:05:34,470
on this course but let me take you out

103
00:05:40,879 --> 00:05:38,160
20 or 30 years to what I think we could

104
00:05:45,230 --> 00:05:40,889
have I think we could have virtual

105
00:05:48,589 --> 00:05:45,240
coverage of our own planet that's active

106
00:05:53,060 --> 00:05:48,599
and passive coverage multispectral with

107
00:05:57,439 --> 00:05:53,070
a matta a small spacecraft hooked up

108
00:05:59,749 --> 00:05:57,449
either through photons or through RF

109
00:06:02,089 --> 00:05:59,759
waves so they're coherently coupled so

110
00:06:05,260 --> 00:06:02,099
we could get pixel registration that

111
00:06:10,370 --> 00:06:05,270
will allow us to understand the stresses

112
00:06:13,129 --> 00:06:10,380
on our life forms the stresses on our

113
00:06:16,129 --> 00:06:13,139

planet so we could understand how to

114
00:06:18,860 --> 00:06:16,139
make rational decisions at the same time

115
00:06:23,360 --> 00:06:18,870
when we have this wonderful data we

116
00:06:26,990 --> 00:06:23,370
could close the biological circle people

117
00:06:29,390 --> 00:06:27,000
are very very isolated from nature today

118
00:06:32,089 --> 00:06:29,400
and I've said this before you know in

119
00:06:35,270 --> 00:06:32,099
big cities like Washington and New York

120
00:06:37,580 --> 00:06:35,280
you know it's fall not by when the

121
00:06:39,260 --> 00:06:37,590
leaves fall off the trees but when the

122
00:06:40,820 --> 00:06:39,270
football season starts you know it's

123
00:06:44,899 --> 00:06:40,830
spring when the baseball season's

124
00:06:48,140 --> 00:06:44,909
thoughts as technological as we are we

125
00:06:51,709 --> 00:06:48,150
are ecologically isolated from our own

126
00:06:54,709 --> 00:06:51,719
environment so by having this ability

127
00:06:57,830 --> 00:06:54,719
which technology could give us it should

128
00:07:00,740 --> 00:06:57,840
be able to close the loop but towards

129
00:07:03,379 --> 00:07:00,750
what purpose are we going in the right

130
00:07:06,399 --> 00:07:03,389
direction and this is what I think we'd

131
00:07:09,560 --> 00:07:06,409
like to explore today the why and the

132
00:07:12,050 --> 00:07:09,570
what not the how because this is what we

133
00:07:13,100 --> 00:07:12,060
concern ourselves with NASA too much how

134
00:07:14,320 --> 00:07:13,110
are we going to do it how many

135
00:07:17,320 --> 00:07:14,330
spacecraft what

136
00:07:19,839 --> 00:07:17,330
look at so we'd like to explore the what

137
00:07:21,490 --> 00:07:19,849
and the why and then understanding the

138
00:07:23,170 --> 00:07:21,500

what and why the problem we could get to

139
00:07:35,679 --> 00:07:23,180
the hell so I look forward to the

140
00:07:37,959 --> 00:07:35,689
discussions today thank you okay our

141
00:07:40,149 --> 00:07:37,969
first speaker to talk about the what and

142
00:07:43,360 --> 00:07:40,159
the why is dr. Ellen stone Mosley

143
00:07:45,429 --> 00:07:43,370
Thompson she received her higher degrees

144
00:07:47,680 --> 00:07:45,439
in climate ology from Ohio State

145
00:07:50,619 --> 00:07:47,690
University and is now an associate

146
00:07:52,659 --> 00:07:50,629
professor there she's also a research

147
00:07:56,529 --> 00:07:52,669
scientist for the Byrd Polar Research

148
00:07:59,469 --> 00:07:56,539
Center's one of her specialties is paleo

149
00:08:01,570 --> 00:07:59,479
climactic reconstructions based on

150
00:08:05,010 --> 00:08:01,580
evidence preserved in ice cores from

151
00:08:07,089 --> 00:08:05,020
Antarctica Greenland China and Peru

152
00:08:09,159 --> 00:08:07,099
she's been involved in global

153
00:08:12,189 --> 00:08:09,169
reconstruction of the Little Ice Age

154
00:08:15,790 --> 00:08:12,199
event the role of volcanism in the last

155
00:08:18,070 --> 00:08:15,800
millennium of climate variability the

156
00:08:20,860 --> 00:08:18,080
reconstruction of abrupt changes in the

157
00:08:24,339 --> 00:08:20,870
environmental system and the impact of

158
00:08:25,930 --> 00:08:24,349
these changes on human activity she has

159
00:08:28,540 --> 00:08:25,940
served as a member of several national

160
00:08:30,309 --> 00:08:28,550
academy and NRC committees and global

161
00:08:32,380 --> 00:08:30,319
change in the environment and is

162
00:08:34,959 --> 00:08:32,390
currently president of the atmospheric

163
00:08:47,699 --> 00:08:34,969

sciences section of the american

164
00:08:54,519 --> 00:08:52,540
thank you dr. Cordova and thank you for

165
00:08:58,600 --> 00:08:54,529
coming and it's quite a pleasure to be

166
00:09:01,569 --> 00:08:58,610
here I'll start with my first slide the

167
00:09:04,930 --> 00:09:01,579
title of my talk is I score records as

168
00:09:09,400 --> 00:09:04,940
windows on the past and keys to our

169
00:09:13,569 --> 00:09:09,410
future I like to start my talks with

170
00:09:16,569 --> 00:09:13,579
this picture this is the margin of the

171
00:09:19,509 --> 00:09:16,579
Cal kaya ice cap which sits in the Andes

172
00:09:22,690 --> 00:09:19,519
of Peru at 14 degrees south at over

173
00:09:25,720 --> 00:09:22,700
6,000 or at about fifty seven hundred

174
00:09:29,550 --> 00:09:25,730
meters what you see here are the annual

175
00:09:34,389 --> 00:09:29,560
layers each of those is the snow that

176
00:09:36,970 --> 00:09:34,399
accumulated in a given year I'll come

177
00:09:41,380 --> 00:09:36,980
full circle at the end of the talk I

178
00:09:43,350 --> 00:09:41,390
will show you how this ice cap no longer

179
00:09:50,889 --> 00:09:43,360
looks this way and it's no longer

180
00:09:53,740 --> 00:09:50,899
preserving this unique archive if we

181
00:09:56,920 --> 00:09:53,750
drill through ice caps and ice sheets we

182
00:10:00,430 --> 00:09:56,930
get an ice core much like this drilled

183
00:10:02,259 --> 00:10:00,440
here using a thermal drill I showed this

184
00:10:06,670 --> 00:10:02,269
some people might not know what a nice

185
00:10:09,100 --> 00:10:06,680
core looks like this slide outlines the

186
00:10:12,310 --> 00:10:09,110
type of environmental data that we get

187
00:10:14,889 --> 00:10:12,320
from ice cores the beauty of an ice core

188
00:10:18,910 --> 00:10:14,899

is it produces a multi-faceted record

189
00:10:21,730 --> 00:10:18,920
it's a cylinder if we take a cut through

190
00:10:24,130 --> 00:10:21,740
there we get a cross-section like this

191
00:10:26,920 --> 00:10:24,140
and then we can partition the samples

192
00:10:28,569 --> 00:10:26,930
and make a variety of measurements for

193
00:10:30,490 --> 00:10:28,579
example one of the most common

194
00:10:33,639 --> 00:10:30,500
measurements is that of the oxygen

195
00:10:37,030 --> 00:10:33,649
isotopic ratio which we use as a proxy

196
00:10:41,230 --> 00:10:37,040
for temperature we can also measure

197
00:10:45,939 --> 00:10:41,240
atmospheric chemistry the dustiness of

198
00:10:48,340 --> 00:10:45,949
the atmosphere vegetation changes not in

199
00:10:51,220 --> 00:10:48,350
the polar regions but outside the polar

200
00:10:54,900 --> 00:10:51,230
regions bulk at the Earth's volcanic

201
00:10:58,569 --> 00:10:54,910
history and as dr. McElroy will show you

202
00:11:02,829 --> 00:10:58,579
anthropogenic emissions carbon dioxide

203
00:11:06,369 --> 00:11:02,839
methane and nitrous oxide in ice course

204
00:11:08,819 --> 00:11:06,379
where we can discern the annual layer we

205
00:11:11,859 --> 00:11:08,829
can say something about how much snow

206
00:11:14,379 --> 00:11:11,869
accumulated in a given year in other

207
00:11:19,169 --> 00:11:14,389
words we can go back and reconstruct the

208
00:11:25,269 --> 00:11:22,720
this slide is busy but it shows all of

209
00:11:28,629 --> 00:11:25,279
the places where we have either had a

210
00:11:31,809 --> 00:11:28,639
nice scoring project or we anticipate

211
00:11:34,239 --> 00:11:31,819
having one in the next slide I'm just

212
00:11:37,239 --> 00:11:34,249
going to show you the upper 40 meters of

213
00:11:40,109 --> 00:11:37,249

a core from the dire plateau located

214
00:11:43,090 --> 00:11:40,119
right here on the Antarctic Peninsula

215
00:11:45,999 --> 00:11:43,100
it's a busy slide I'd like to call your

216
00:11:49,710 --> 00:11:46,009
attention to these two profiles the

217
00:11:52,660 --> 00:11:49,720
oxygen isotopic ratio and the sulfate

218
00:11:56,199 --> 00:11:52,670
concentrations this is just the upper 40

219
00:11:59,319 --> 00:11:56,209
meters of a 200-meter core I'm using

220
00:12:02,559 --> 00:11:59,329
this to illustrate to you how we date

221
00:12:05,619 --> 00:12:02,569
course ideally we like to date them year

222
00:12:08,499 --> 00:12:05,629
by year to do that requires that we

223
00:12:11,639 --> 00:12:08,509
discern or measure something that has a

224
00:12:14,949 --> 00:12:11,649
seasonal signal and here in Delta o-18

225
00:12:18,669 --> 00:12:14,959
we see summer winter summer winter

226
00:12:22,030 --> 00:12:18,679
summer winter we see high flux of

227
00:12:24,429 --> 00:12:22,040
sulfate every spring so essentially we

228
00:12:27,429 --> 00:12:24,439
can drill through it's like a layer cake

229
00:12:29,379 --> 00:12:27,439
and when the accumulation rate is high

230
00:12:32,350 --> 00:12:29,389
enough we pick up these seasonal

231
00:12:37,900 --> 00:12:32,360
variations and we can precisely date

232
00:12:39,999 --> 00:12:37,910
these cores these cores provide an

233
00:12:42,699 --> 00:12:40,009
opportunity to reconstruct the Earth's

234
00:12:46,569 --> 00:12:42,709
volcanic history this happens to be the

235
00:12:50,109 --> 00:12:46,579
eruption of mount pinatubo in 91 and we

236
00:12:54,210 --> 00:12:50,119
know that it the sulfur the sulfuric

237
00:12:59,169 --> 00:12:54,220
acid droplets have essentially the

238
00:13:02,169 --> 00:12:59,179

cooling in 92 and 93 was attributed to

239
00:13:06,220 --> 00:13:02,179
the sulfuric acid suspended in the

240
00:13:08,650 --> 00:13:06,230
stratosphere well we can take a record

241
00:13:11,879 --> 00:13:08,660
like that with ice cores and go back in

242
00:13:16,289 --> 00:13:11,889
time this again a busy slide but the

243
00:13:19,799 --> 00:13:16,299
to this is excess sulfate we have to

244
00:13:22,109 --> 00:13:19,809
extract the oceanic sulfate component

245
00:13:25,710 --> 00:13:22,119
and we do that by measuring chlorine or

246
00:13:28,979 --> 00:13:25,720
sodium what we are left with is the

247
00:13:33,389 --> 00:13:28,989
excess and the two prominent sources of

248
00:13:35,759 --> 00:13:33,399
excess sulfate are volcanism and the

249
00:13:38,519 --> 00:13:35,769
burning of fossil fuels both of which we

250
00:13:41,819 --> 00:13:38,529
see in this diagram these are the

251
00:13:43,979 --> 00:13:41,829
individual eruptions the spikes this is

252
00:13:47,269 --> 00:13:43,989
Northern Hemisphere two sites in

253
00:13:50,549 --> 00:13:47,279
Greenland and two sites in Antarctica

254
00:13:52,530 --> 00:13:50,559
and you can see that although there are

255
00:13:55,349 --> 00:13:52,540
many many eruptions in the northern

256
00:13:57,479 --> 00:13:55,359
hemisphere those eruptions that are

257
00:14:00,720 --> 00:13:57,489
preserved both in the North and the

258
00:14:03,840 --> 00:14:00,730
South are much fewer I'd point out the

259
00:14:08,309 --> 00:14:03,850
eruption of tambora right here it's part

260
00:14:12,150 --> 00:14:08,319
of this couplet tambora erupted in 1815

261
00:14:15,629 --> 00:14:12,160
and it was credited with the year

262
00:14:17,429 --> 00:14:15,639
without a summer in 1816 however if you

263
00:14:20,369 --> 00:14:17,439

go back and you look at the climate

264
00:14:22,590 --> 00:14:20,379
history the temperature records it was

265
00:14:26,129 --> 00:14:22,600
found that actually the climate in that

266
00:14:28,409 --> 00:14:26,139
decade from 1810 to 1820 the

267
00:14:32,340 --> 00:14:28,419
temperatures were actually declining

268
00:14:35,699 --> 00:14:32,350
before tambora erupted and this was used

269
00:14:39,960 --> 00:14:35,709
as evidence against the potential of a

270
00:14:42,780 --> 00:14:39,970
volcano temperature linkage however with

271
00:14:47,519 --> 00:14:42,790
these ice cores putting them together we

272
00:14:50,309 --> 00:14:47,529
found another eruption in 1809 virtually

273
00:14:53,100 --> 00:14:50,319
the same magnitude as tambora very

274
00:14:56,279 --> 00:14:53,110
outstanding event of the same magnitude

275
00:14:59,210 --> 00:14:56,289
in terms of the sulfate it produced in

276
00:15:02,909 --> 00:14:59,220
the northern hemisphere but not recorded

277
00:15:06,059 --> 00:15:02,919
historically but well preserved in the

278
00:15:08,939 --> 00:15:06,069
ice core and we speculate that was this

279
00:15:11,879 --> 00:15:08,949
eruption in 1809 that really set the

280
00:15:13,739 --> 00:15:11,889
stage for the cooling of that decade and

281
00:15:18,090 --> 00:15:13,749
then of course adding insult to injury

282
00:15:21,900 --> 00:15:18,100
with tambora we recorded the lowest the

283
00:15:25,390 --> 00:15:21,910
decade 1810 to 1820 the lowest

284
00:15:30,350 --> 00:15:28,430
when we collect the ice course from many

285
00:15:33,320 --> 00:15:30,360
locations in other words we have a

286
00:15:35,420 --> 00:15:33,330
diversity of ice core records we can

287
00:15:40,510 --> 00:15:35,430
begin to study different components of

288
00:15:43,700 --> 00:15:40,520

the earth system just a brief word about

289
00:15:46,460 --> 00:15:43,710
preliminary results actually this was a

290
00:15:51,260 --> 00:15:46,470
small project preliminary funded by NASA

291
00:15:54,740 --> 00:15:51,270
to look at the ice caps in franz josef

292
00:15:58,100 --> 00:15:54,750
land in the rut in the Russian Arctic

293
00:16:01,550 --> 00:15:58,110
and franz josef land located here at 80

294
00:16:05,720 --> 00:16:01,560
degrees north is the furthest north land

295
00:16:08,870 --> 00:16:05,730
mass in that sector we looked at five

296
00:16:11,240 --> 00:16:08,880
different ice caps and we found that on

297
00:16:14,570 --> 00:16:11,250
the island of Graham Bell the windy dome

298
00:16:17,590 --> 00:16:14,580
ice cap contains a reasonably well

299
00:16:20,240 --> 00:16:17,600
preserved record and is 500 meters thick

300
00:16:22,880 --> 00:16:20,250
now give you these data are very

301
00:16:25,580 --> 00:16:22,890
preliminary we were only drilling with a

302
00:16:28,250 --> 00:16:25,590
hand auger this means we extracted a

303
00:16:32,120 --> 00:16:28,260
20-metre core so the record does not go

304
00:16:35,780 --> 00:16:32,130
back very long in time but what we found

305
00:16:38,290 --> 00:16:35,790
is that increased chloride concentration

306
00:16:41,780 --> 00:16:38,300
chloride isn't green that when chloride

307
00:16:45,980 --> 00:16:41,790
concentration is high the concentration

308
00:16:48,470 --> 00:16:45,990
of sea ice in that area is low so in

309
00:16:51,680 --> 00:16:48,480
other words low sea ice more open water

310
00:16:54,410 --> 00:16:51,690
a greater concentration of chloride and

311
00:16:56,480 --> 00:16:54,420
the r-square this is only a 10 year

312
00:16:58,550 --> 00:16:56,490
record but they are square or

313
00:17:02,630 --> 00:16:58,560

coefficient of determination is 0 point

314
00:17:06,410 --> 00:17:02,640
3 4 it's pretty good to explain 4334

315
00:17:08,360 --> 00:17:06,420
percent of the variance and this is just

316
00:17:11,260 --> 00:17:08,370
a linear plot of the increase in

317
00:17:13,939 --> 00:17:11,270
chloride against the decrease in sea ice

318
00:17:16,970 --> 00:17:13,949
concentration so we're optimistic that

319
00:17:20,800 --> 00:17:16,980
course particularly from the windy dome

320
00:17:25,370 --> 00:17:20,810
may provide a long record of sea ice

321
00:17:27,710 --> 00:17:25,380
variability I'd like to move to the

322
00:17:31,970 --> 00:17:27,720
southern hemisphere to the cal kaya ice

323
00:17:35,840 --> 00:17:31,980
cap it sits at about 18,000 feet in the

324
00:17:37,250 --> 00:17:35,850
Andes at 14 degrees south this was

325
00:17:39,530 --> 00:17:37,260
actually one of the first

326
00:17:43,760 --> 00:17:39,540
drilling projects outside the polar

327
00:17:46,760 --> 00:17:43,770
regions kal kya sits here it covers

328
00:17:48,920 --> 00:17:46,770
about 60 square kilometers the local

329
00:17:52,850 --> 00:17:48,930
mode of transportation shows you that it

330
00:17:56,690 --> 00:17:52,860
is a very remote area the precipitation

331
00:17:58,940 --> 00:17:56,700
to this ice cap comes from the Andes in

332
00:18:01,130 --> 00:17:58,950
the form of these convective storms

333
00:18:03,620 --> 00:18:01,140
these are people on the surface for

334
00:18:08,830 --> 00:18:03,630
scale just to show you that once you're

335
00:18:11,720 --> 00:18:08,840
up on these ice caps they are very large

336
00:18:14,480 --> 00:18:11,730
this was the first use of solar power

337
00:18:17,510 --> 00:18:14,490
because of the remote nature of the site

338
00:18:20,870 --> 00:18:17,520

it was virtually impossible to drill

339
00:18:26,510 --> 00:18:20,880
this in the usual antarctic tradition

340
00:18:29,030 --> 00:18:26,520
and we used 60 solar panels to extract

341
00:18:32,060 --> 00:18:29,040
two cores to bedrock now this is the

342
00:18:34,760 --> 00:18:32,070
same ice cap in which i initially showed

343
00:18:36,260 --> 00:18:34,770
you that vertical margin and this is

344
00:18:39,230 --> 00:18:36,270
what it looks like if you drill through

345
00:18:42,320 --> 00:18:39,240
it these are core sections and these are

346
00:18:44,480 --> 00:18:42,330
those visible dust bands at a hundred

347
00:18:47,030 --> 00:18:44,490
and thirty nine meters in the core we

348
00:18:49,640 --> 00:18:47,040
still have well-preserved s bands this

349
00:18:54,860 --> 00:18:49,650
is what i mean by annual resolution

350
00:18:58,580 --> 00:18:54,870
where we count back year by year the kel

351
00:19:01,040 --> 00:18:58,590
kya provided a 1500 year record from

352
00:19:04,330 --> 00:19:01,050
this region the first record of that

353
00:19:08,390 --> 00:19:04,340
length of that quality from the tropics

354
00:19:12,740 --> 00:19:08,400
we extracted a history of the dustiness

355
00:19:14,380 --> 00:19:12,750
of the atmosphere the accumulation in

356
00:19:18,500 --> 00:19:14,390
other words the changes in precipitation

357
00:19:20,750 --> 00:19:18,510
and the oxygen isotopic ratio tells us

358
00:19:23,060 --> 00:19:20,760
something about temperature and I want

359
00:19:26,510 --> 00:19:23,070
to focus in the next few slides just on

360
00:19:30,290 --> 00:19:26,520
this record the 0 18 and this feature

361
00:19:36,350 --> 00:19:30,300
here which is the little ice age and the

362
00:19:38,570 --> 00:19:36,360
precipitation history on the the bottom

363
00:19:41,870 --> 00:19:38,580

or the bottom and the middle graph are

364
00:19:46,970 --> 00:19:41,880
the oxygen isotopic records going back

365
00:19:49,910 --> 00:19:46,980
to 1600 from kal kya we always drill to

366
00:19:53,000 --> 00:19:49,920
parallel course at a minimum the reason

367
00:19:56,090 --> 00:19:53,010
is if you find something unusual in your

368
00:19:59,920 --> 00:19:56,100
core history and you cannot replicate it

369
00:20:02,570 --> 00:19:59,930
in a parallel core then you have to

370
00:20:05,000 --> 00:20:02,580
suspect it may be you have an artifact

371
00:20:09,400 --> 00:20:05,010
if you can reproduce it it gives you

372
00:20:13,310 --> 00:20:09,410
confidence that you are reconstructing a

373
00:20:15,980 --> 00:20:13,320
respectable history so you can see the

374
00:20:19,100 --> 00:20:15,990
two cores give essentially the same

375
00:20:22,300 --> 00:20:19,110
isotopic results but we've plotted those

376
00:20:26,480 --> 00:20:22,310
here against the northern hemisphere

377
00:20:28,700 --> 00:20:26,490
10-year average temperatures and I'd

378
00:20:32,300 --> 00:20:28,710
like to point out two things first you

379
00:20:36,170 --> 00:20:32,310
can see that the general shape of the

380
00:20:39,050 --> 00:20:36,180
curves is very similar secondly that

381
00:20:41,080 --> 00:20:39,060
this Little Ice Age period and you'll

382
00:20:44,090 --> 00:20:41,090
hear more about that from dr. McElroy

383
00:20:46,330 --> 00:20:44,100
but it was essentially a cool phase in

384
00:20:49,460 --> 00:20:46,340
the Earth's climate history from around

385
00:20:51,770 --> 00:20:49,470
1450 to about eighteen eighty ad in

386
00:20:55,220 --> 00:20:51,780
which it's estimated that temperatures

387
00:20:56,870 --> 00:20:55,230
were about a half a degree cooler also

388
00:20:59,570 --> 00:20:56,880

notice this decade that I've already

389
00:21:03,560 --> 00:20:59,580
mentioned the coolest decade on record

390
00:21:06,800 --> 00:21:03,570
18 10 to 18 20 faithfully recorded by

391
00:21:13,730 --> 00:21:06,810
this ice cap at 18,000 feet at 14

392
00:21:16,400 --> 00:21:13,740
degrees south south america is very rich

393
00:21:21,980 --> 00:21:16,410
in archaeological history this happens

394
00:21:25,160 --> 00:21:21,990
to be Machu Picchu in this slide we've

395
00:21:28,700 --> 00:21:25,170
plotted the 1500 year record of net

396
00:21:31,640 --> 00:21:28,710
accumulation showing essentially periods

397
00:21:33,950 --> 00:21:31,650
where we had less accumulation and more

398
00:21:37,280 --> 00:21:33,960
accumulation in the southern highlands

399
00:21:40,160 --> 00:21:37,290
of Peru over here we're looking at the

400
00:21:42,770 --> 00:21:40,170
rise in the fall of the cultures in that

401
00:21:44,840 --> 00:21:42,780
area and I want you to focus on the

402
00:21:49,670 --> 00:21:44,850
cultures here in the southern highlands

403
00:21:53,030 --> 00:21:49,680
and we can see that during this this

404
00:21:57,650 --> 00:21:53,040
time we have fairly high accumulation

405
00:22:00,310 --> 00:21:57,660
and we have this particular culture the

406
00:22:04,330 --> 00:22:00,320
whorey culture

407
00:22:07,600 --> 00:22:04,340
as we enter this period of reduced

408
00:22:10,960 --> 00:22:07,610
accumulation that culture essentially

409
00:22:13,629 --> 00:22:10,970
leaves the highlands and the cultures

410
00:22:15,909 --> 00:22:13,639
that does not return to the southern

411
00:22:19,330 --> 00:22:15,919
highlands of Peru until this more

412
00:22:22,180 --> 00:22:19,340
pluvial period and this is actually was

413
00:22:24,850 --> 00:22:22,190

the rise of the Inca Empire and of

414
00:22:27,789 --> 00:22:24,860
course determination is the entry of

415
00:22:30,220 --> 00:22:27,799
Spanish into South America when all of

416
00:22:33,730 --> 00:22:30,230
the Highland when all of the cultures

417
00:22:37,810 --> 00:22:33,740
essentially ceased what we know is that

418
00:22:39,850 --> 00:22:37,820
the Highland that the the cultures in

419
00:22:42,330 --> 00:22:39,860
the highland areas and in the coastal

420
00:22:45,759 --> 00:22:42,340
areas tend to function in anti-phase

421
00:22:50,710 --> 00:22:45,769
that is when one culture is flourishing

422
00:22:52,720 --> 00:22:50,720
another culture is diminishing and when

423
00:22:57,789 --> 00:22:52,730
I talk about El Nino here in a minute I

424
00:23:02,560 --> 00:22:57,799
want you to remember this the general

425
00:23:05,889 --> 00:23:02,570
the climate in Peru is dominated by the

426
00:23:09,430 --> 00:23:05,899
El Nino and that system called El Nino

427
00:23:11,710 --> 00:23:09,440
Southern Oscillation or ENSO essentially

428
00:23:14,560 --> 00:23:11,720
during in so we get drought conditions

429
00:23:20,019 --> 00:23:14,570
in southern Peru and flooding conditions

430
00:23:21,700 --> 00:23:20,029
in northern Peru along the coast it just

431
00:23:24,310 --> 00:23:21,710
happened that the drilling project on

432
00:23:28,060 --> 00:23:24,320
kal kya the big drilling project

433
00:23:32,049 --> 00:23:28,070
occurred in 1983 in the middle of the

434
00:23:37,690 --> 00:23:32,059
mega El Nino of 82 83 the largest in so

435
00:23:40,299 --> 00:23:37,700
on record on this side we see the kel

436
00:23:44,019 --> 00:23:40,309
kya ice cap as it normally appears in

437
00:23:47,169 --> 00:23:44,029
19th it appeared in 1978 these are

438
00:23:51,960 --> 00:23:47,179

people for scale this is the same shot

439
00:23:54,490 --> 00:23:51,970
taken in 1983 and you can see that the

440
00:23:59,830 --> 00:23:54,500
essentially the drought in that area is

441
00:24:02,649 --> 00:23:59,840
taking a toll on that ice cap this is

442
00:24:05,200 --> 00:24:02,659
just a very short record of the annual

443
00:24:07,480 --> 00:24:05,210
layer thicknesses essentially what we

444
00:24:11,049 --> 00:24:07,490
found is that during the end so the

445
00:24:13,680 --> 00:24:11,059
accumulation rate on this ice cap drops

446
00:24:20,340 --> 00:24:13,690
by at least twenty five percent

447
00:24:25,320 --> 00:24:20,350
this is the 82 83 El Nino and the 76 77

448
00:24:27,480 --> 00:24:25,330
El Nino so we were encouraged that the

449
00:24:30,210 --> 00:24:27,490
ability to reconstruct these annual

450
00:24:33,360 --> 00:24:30,220
layers and their thicknesses might allow

451
00:24:36,600 --> 00:24:33,370
us to reconstruct a much longer record

452
00:24:39,180 --> 00:24:36,610
of El Nino Southern Oscillation for this

453
00:24:42,799 --> 00:24:39,190
region and in fact we have here the last

454
00:24:47,240 --> 00:24:42,809
500 years it's very very busy slide and

455
00:24:50,789 --> 00:24:47,250
we have plotted here the El Ninos as

456
00:24:54,419 --> 00:24:50,799
reconstructed by bill Quinn back to 1500

457
00:24:57,810 --> 00:24:54,429
ad to make a long story short we

458
00:25:00,299 --> 00:24:57,820
essentially found that many of the that

459
00:25:03,960 --> 00:25:00,309
most of the in cells were recorded in

460
00:25:07,470 --> 00:25:03,970
kal kya as thin layers but we had more

461
00:25:09,360 --> 00:25:07,480
thin layers than we had in so and if you

462
00:25:11,430 --> 00:25:09,370
think about it it makes sense in that

463
00:25:13,379 --> 00:25:11,440

there are many other reasons why you

464
00:25:17,399 --> 00:25:13,389
would have a year with reduced

465
00:25:19,710 --> 00:25:17,409
accumulation later I'll show you I'm not

466
00:25:21,539 --> 00:25:19,720
going to follow up on the in so part but

467
00:25:23,820 --> 00:25:21,549
we've just completed a project in

468
00:25:25,830 --> 00:25:23,830
northern Peru in the previous slide

469
00:25:29,159 --> 00:25:25,840
remember northern Peru gets more

470
00:25:32,100 --> 00:25:29,169
accumulation so we now hope to put these

471
00:25:35,909 --> 00:25:32,110
two records together matching in the

472
00:25:40,830 --> 00:25:35,919
South thin years within the North thick

473
00:25:44,340 --> 00:25:40,840
years and see if we can better calibrate

474
00:25:49,230 --> 00:25:44,350
our current ability to reconstruct El

475
00:25:51,450 --> 00:25:49,240
Nino Southern Oscillation ice cores also

476
00:25:55,560 --> 00:25:51,460
have the ability to provide us a

477
00:25:57,930 --> 00:25:55,570
long-term perspective and this

478
00:26:00,240 --> 00:25:57,940
perspective is critical if we're going

479
00:26:02,970 --> 00:26:00,250
to understand the natural variability of

480
00:26:05,669 --> 00:26:02,980
the climate system and we must

481
00:26:09,690 --> 00:26:05,679
understand the natural variability if

482
00:26:13,769 --> 00:26:09,700
we're going to separate it from recent

483
00:26:15,720 --> 00:26:13,779
anthropogenic effects we all run up

484
00:26:18,240 --> 00:26:15,730
against this all the time well how do

485
00:26:20,639 --> 00:26:18,250
you know the 20th century is unusual how

486
00:26:23,279 --> 00:26:20,649
do you know that the 1980s were unusual

487
00:26:25,980 --> 00:26:23,289
the only way you know is to look back

488
00:26:26,549 --> 00:26:25,990

through time and use that history as a

489
00:26:32,220 --> 00:26:26,559
measure

490
00:26:36,060 --> 00:26:32,230
stick I want to move now from kal kya

491
00:26:38,519 --> 00:26:36,070
cross the Pacific Basin to the Tibetan

492
00:26:41,399 --> 00:26:38,529
Plateau I would just point out this is a

493
00:26:44,549 --> 00:26:41,409
NASA image taken I think this is

494
00:26:51,720 --> 00:26:44,559
November of 82 and you see here the

495
00:26:53,999 --> 00:26:51,730
Pacific warm pool in Asia the dominant

496
00:26:57,629 --> 00:26:54,009
climate system is the monsoonal

497
00:27:00,029 --> 00:26:57,639
circulation system and the monsoonal

498
00:27:03,239 --> 00:27:00,039
circulation system is driven primarily

499
00:27:06,960 --> 00:27:03,249
by the intense heating of the Tibetan

500
00:27:10,080 --> 00:27:06,970
Plateau the Tibetan Plateau is the most

501
00:27:14,070 --> 00:27:10,090
outstanding feature on the earth it has

502
00:27:17,789 --> 00:27:14,080
an elevation of over 4,500 meters and it

503
00:27:23,850 --> 00:27:17,799
contains over 60,000 square kilometers

504
00:27:26,639 --> 00:27:23,860
of snow and ice this is the dune to ice

505
00:27:30,090 --> 00:27:26,649
cap located in the north on the north

506
00:27:32,489 --> 00:27:30,100
central part of the Tibetan Plateau for

507
00:27:37,580 --> 00:27:32,499
scale this is a party with horses going

508
00:27:40,529 --> 00:27:37,590
to the summit the dune to ice cap if

509
00:27:44,249 --> 00:27:40,539
epitomizes what we call an ideal ice cap

510
00:27:46,259 --> 00:27:44,259
shown here in a schematic and what we

511
00:27:49,590 --> 00:27:46,269
look for in these drilling projects are

512
00:27:54,710 --> 00:27:49,600
dome shaped ice masses with relatively

513
00:27:59,549 --> 00:27:54,720

flat basil bedrock so that the flow

514
00:28:02,549 --> 00:27:59,559
regime is fairly simple but for any ice

515
00:28:04,619 --> 00:28:02,559
sheet ice cap there are three things

516
00:28:07,169 --> 00:28:04,629
that determine the length of the record

517
00:28:10,470 --> 00:28:07,179
that you will get the first is the

518
00:28:14,279 --> 00:28:10,480
amount of accumulation that falls the

519
00:28:16,919 --> 00:28:14,289
second is how thick is the ice and the

520
00:28:19,649 --> 00:28:16,929
third is whether that ice is frozen to

521
00:28:22,049 --> 00:28:19,659
the bedrock because of course if it's

522
00:28:27,119 --> 00:28:22,059
not frozen to the bedrock you're losing

523
00:28:30,299 --> 00:28:27,129
your record from below in theory weren't

524
00:28:34,470 --> 00:28:30,309
your ice cap frozen to the bedrock and

525
00:28:37,009 --> 00:28:34,480
had it been so throughout time the first

526
00:28:39,780 --> 00:28:37,019
snow that fell in that region

527
00:28:42,780 --> 00:28:39,790
theoretically should still be there

528
00:28:45,820 --> 00:28:42,790
we know however that it would be thinned

529
00:28:48,880 --> 00:28:45,830
infant essa melis mall and could not be

530
00:28:55,630 --> 00:28:48,890
discernible but the idea is you want to

531
00:28:59,350 --> 00:28:55,640
look for ice caps frozen to the bed the

532
00:29:02,110 --> 00:28:59,360
oxygen isotopic record that I've been

533
00:29:05,590 --> 00:29:02,120
talking about we use Delta o-18 as a

534
00:29:08,380 --> 00:29:05,600
proxy for temperature and I just want to

535
00:29:11,140 --> 00:29:08,390
show you because we have had this long

536
00:29:13,240 --> 00:29:11,150
term collaborative project in China we

537
00:29:16,419 --> 00:29:13,250
have the ability to have snowfall

538
00:29:19,690 --> 00:29:16,429

collected and the temperature measured

539
00:29:21,430 --> 00:29:19,700
at the same time contemporaneously this

540
00:29:24,310 --> 00:29:21,440
is something that is very difficult to

541
00:29:27,250 --> 00:29:24,320
do over the polar ice sheets essentially

542
00:29:30,160 --> 00:29:27,260
we have the Delta o-18 here and the

543
00:29:34,330 --> 00:29:30,170
temperature we have more negative Delta

544
00:29:38,910 --> 00:29:34,340
when we have colder temperatures less

545
00:29:41,919 --> 00:29:38,920
negative Delta and warmer temperatures

546
00:29:44,860 --> 00:29:41,929
the dune to ice cap contained a record

547
00:29:47,919 --> 00:29:44,870
well over 40,000 years long this was a

548
00:29:50,560 --> 00:29:47,929
surprise to us actually we had

549
00:29:55,419 --> 00:29:50,570
anticipated a record maybe a five to ten

550
00:29:58,710 --> 00:29:55,429
thousand this is the this they do the

551
00:30:02,080 --> 00:29:58,720
course represent the very first ice

552
00:30:05,230 --> 00:30:02,090
recovered outside the polar regions that

553
00:30:10,330 --> 00:30:05,240
contain ice deposited during the last

554
00:30:12,610 --> 00:30:10,340
glaciation over 12,000 years ago but

555
00:30:16,480 --> 00:30:12,620
more importantly it provides that

556
00:30:20,140 --> 00:30:16,490
backdrop or that measuring stick let me

557
00:30:25,480 --> 00:30:20,150
use this to illustrate this is a 12,000

558
00:30:28,690 --> 00:30:25,490
year record of Delta o-18 more negative

559
00:30:32,320 --> 00:30:28,700
is cold and what we see here is the end

560
00:30:35,770 --> 00:30:32,330
of the last major glaciation and the

561
00:30:39,610 --> 00:30:35,780
overlying Holocene the shaded area

562
00:30:45,490 --> 00:30:39,620
represents the Delta o-18 average for

563
00:30:49,630 --> 00:30:45,500

the last 50 years 1937 to 1987 the year

564
00:30:52,540 --> 00:30:49,640
we drilled the core as you can see the

565
00:30:57,940 --> 00:30:52,550
last 50 years have been the warmest

566
00:31:01,600 --> 00:30:57,950
in the last 12,000 now climate models

567
00:31:04,180 --> 00:31:01,610
which we know are in precise and

568
00:31:08,430 --> 00:31:04,190
imperfect and dr. McElroy will mention

569
00:31:12,700 --> 00:31:08,440
that I'm sure given all their warts

570
00:31:16,330 --> 00:31:12,710
still suggest that the interior hi

571
00:31:18,910 --> 00:31:16,340
portions of large continents should be

572
00:31:21,670 --> 00:31:18,920
one of the first places where we would

573
00:31:25,150 --> 00:31:21,680
see evidence of an anthropogenic ly

574
00:31:28,240 --> 00:31:25,160
induced warming and that's what we see

575
00:31:32,470 --> 00:31:28,250
here at over 5,000 meters on the Tibetan

576
00:31:34,690 --> 00:31:32,480
Plateau I just want to point out that

577
00:31:38,110 --> 00:31:34,700
the types of projects that we conduct

578
00:31:40,270 --> 00:31:38,120
require international collaboration we

579
00:31:42,970 --> 00:31:40,280
could not do projects in China and South

580
00:31:45,490 --> 00:31:42,980
America without our international

581
00:31:48,730 --> 00:31:45,500
partners I'd like to move now from the

582
00:31:53,590 --> 00:31:48,740
dune to ice cap here to the Galia ice

583
00:31:56,760 --> 00:31:53,600
cap in the Western Kunlun galia sits at

584
00:31:59,650 --> 00:31:56,770
sixty seven hundred metres that's over

585
00:32:04,330 --> 00:31:59,660
21,000 feet and you see it here

586
00:32:08,860 --> 00:32:04,340
virtually in the clouds but it has

587
00:32:11,740 --> 00:32:08,870
annual layering and this vertical margin

588
00:32:15,160 --> 00:32:11,750

that you see tells us that it is frozen

589
00:32:19,180 --> 00:32:15,170
to the bed this is the profile that one

590
00:32:24,850 --> 00:32:19,190
expects to see I on polar glaciers that

591
00:32:29,680 --> 00:32:24,860
are frozen to the bed and this is just a

592
00:32:32,620 --> 00:32:29,690
drill site of the drill camp and again

593
00:32:35,380 --> 00:32:32,630
in this ice cap these are the annual

594
00:32:38,800 --> 00:32:35,390
layers that have allowed us to count

595
00:32:41,110 --> 00:32:38,810
back what to point out that at a hundred

596
00:32:44,920 --> 00:32:41,120
and thirty five meters we are still

597
00:32:48,990 --> 00:32:44,930
counting annual layers we encountered

598
00:32:52,630 --> 00:32:49,000
late glacial stage ice at a hundred and

599
00:32:56,410 --> 00:32:52,640
fifty three meters on this ice cap that

600
00:32:58,870 --> 00:32:56,420
should be the next slide the ice the ice

601
00:33:02,500 --> 00:32:58,880
caps three hundred and seven meters

602
00:33:04,820 --> 00:33:02,510
thick we essentially layer counted to

603
00:33:06,950 --> 00:33:04,830
right here

604
00:33:09,580 --> 00:33:06,960
we had estimated that we should

605
00:33:13,159 --> 00:33:09,590
encounter late glacial stage that's

606
00:33:16,100 --> 00:33:13,169
12,000 years or older ice at a hundred

607
00:33:21,019 --> 00:33:16,110
and fifty five meters we encountered it

608
00:33:23,870 --> 00:33:21,029
at 153 these analyses are still under

609
00:33:26,450 --> 00:33:23,880
we're still making the analyses we're

610
00:33:30,080 --> 00:33:26,460
halfway through but what I want to point

611
00:33:32,720 --> 00:33:30,090
out is we have late glacial stage ice

612
00:33:35,230 --> 00:33:32,730
this is the second time we've found late

613
00:33:38,629 --> 00:33:35,240

glacial stage ice on the Tibetan Plateau

614
00:33:41,480 --> 00:33:38,639
but we still have half the thickness of

615
00:33:43,610 --> 00:33:41,490
that ice cap get to analyze so we

616
00:33:48,110 --> 00:33:43,620
anticipate that we're going to have a

617
00:33:50,299 --> 00:33:48,120
record of multiple glaciations when we

618
00:33:52,909 --> 00:33:50,309
begin to put together a global array of

619
00:33:56,860 --> 00:33:52,919
records we begin to see large-scale

620
00:34:01,720 --> 00:33:56,870
teleconnections this is the accumulation

621
00:34:05,269 --> 00:34:01,730
from the Galia core the last 1000 years

622
00:34:09,970 --> 00:34:05,279
compared to the cal kaya core the

623
00:34:13,909 --> 00:34:09,980
similarity is is striking hi

624
00:34:17,540 --> 00:34:13,919
accumulation low accumulation when you

625
00:34:19,940 --> 00:34:17,550
consider that the Galia sits on the far

626
00:34:25,220 --> 00:34:19,950
western edge of the Tibetan Plateau at

627
00:34:27,829 --> 00:34:25,230
35 degrees north kal kya sits 20,000

628
00:34:33,770 --> 00:34:27,839
kilometers away across the Pacific Basin

629
00:34:37,159 --> 00:34:33,780
at 14 degrees south in the Andes we know

630
00:34:39,649 --> 00:34:37,169
from current day observations that the

631
00:34:42,859 --> 00:34:39,659
El Nino Southern Oscillation dominates

632
00:34:46,520 --> 00:34:42,869
the Pacific Basin and we also know that

633
00:34:50,599 --> 00:34:46,530
its variability is tied intimately to

634
00:34:54,829 --> 00:34:50,609
the monsoonal circulation system and the

635
00:34:59,109 --> 00:34:54,839
failure of the monsoons we've proposed

636
00:35:03,740 --> 00:34:59,119
that the earth actually has what we call

637
00:35:05,960 --> 00:35:03,750
excuse me mega El Ninos periods of time

638
00:35:10,400 --> 00:35:05,970

for hundreds of years in which the earth

639
00:35:13,280 --> 00:35:10,410
operates in an El Nino like state we

640
00:35:16,260 --> 00:35:13,290
know El Ninos today last 1 or 2 years

641
00:35:18,930 --> 00:35:16,270
although in the last decade

642
00:35:22,020 --> 00:35:18,940
you haven't it hasn't operated quite the

643
00:35:24,000 --> 00:35:22,030
way we thought it should the point is

644
00:35:26,150 --> 00:35:24,010
what you begin to collect these records

645
00:35:30,660 --> 00:35:26,160
you can begin to put these connections

646
00:35:33,690 --> 00:35:30,670
together this is again a busy slide this

647
00:35:36,660 --> 00:35:33,700
shows the 10-year averages for the last

648
00:35:39,510 --> 00:35:36,670
1000 years from nine different ice core

649
00:35:42,390 --> 00:35:39,520
sites all the way from South Pole

650
00:35:47,070 --> 00:35:42,400
Station to central Greenland and camp

651
00:35:49,110 --> 00:35:47,080
century maybe those people who would

652
00:35:51,240 --> 00:35:49,120
like to believe that the little ice age

653
00:35:54,270 --> 00:35:51,250
is a global phenomenon might be

654
00:35:57,480 --> 00:35:54,280
disappointed because what we see is that

655
00:36:00,240 --> 00:35:57,490
in Peru the little ice age was a very

656
00:36:03,120 --> 00:36:00,250
dominant feature it's recorded in the

657
00:36:05,850 --> 00:36:03,130
Greenland course it's also recorded at

658
00:36:09,140 --> 00:36:05,860
South Pole Station but we do not have

659
00:36:12,810 --> 00:36:09,150
evidence of the Little Ice Age in China

660
00:36:15,570 --> 00:36:12,820
if you were to take 11 meteorological

661
00:36:19,770 --> 00:36:15,580
stations chosen at random but to give a

662
00:36:23,910 --> 00:36:19,780
global coverage I suggest that you would

663
00:36:26,160 --> 00:36:23,920

not find coherences any stronger than

664
00:36:30,810 --> 00:36:26,170
these it is very difficult to

665
00:36:33,240 --> 00:36:30,820
reconstruct climate from point sites but

666
00:36:35,070 --> 00:36:33,250
that's what we have to do the one

667
00:36:38,250 --> 00:36:35,080
feature that comes through very clearly

668
00:36:46,500 --> 00:36:38,260
in this record is the warming of the

669
00:36:49,560 --> 00:36:46,510
last century and a half when we go

670
00:36:52,560 --> 00:36:49,570
places in drill new ice cores we find

671
00:36:56,360 --> 00:36:52,570
that they often challenged our existing

672
00:36:59,670 --> 00:36:56,370
paradigms the way we think about things

673
00:37:05,070 --> 00:36:59,680
want to return now to Peru but go to

674
00:37:07,260 --> 00:37:05,080
northern Peru to a site crossed Quran we

675
00:37:12,090 --> 00:37:07,270
drilled here in this call at a little

676
00:37:16,260 --> 00:37:12,100
over 6,000 meters the access was

677
00:37:19,500 --> 00:37:16,270
difficult this is the drill cap in the

678
00:37:25,320 --> 00:37:19,510
call and this was the second use of

679
00:37:28,320 --> 00:37:25,330
solar power for ice core drilling to

680
00:37:30,420 --> 00:37:28,330
date the core we again count annual

681
00:37:33,750 --> 00:37:30,430
layers I'm showing you just

682
00:37:36,900 --> 00:37:33,760
four sections from the core each section

683
00:37:41,210 --> 00:37:36,910
with the same three parameters used for

684
00:37:46,349 --> 00:37:41,220
dating Dust oxygen isotopic ratios and

685
00:37:49,589 --> 00:37:46,359
nitrate concentrations in green this

686
00:37:53,370 --> 00:37:49,599
diagram shows the layer thinning with

687
00:37:55,410 --> 00:37:53,380
depth and we we thin essentially from a

688
00:38:00,750 --> 00:37:55,420

layer thickness of about a metre and a

689
00:38:06,089 --> 00:38:00,760
half of water equivalent very quickly we

690
00:38:09,120 --> 00:38:06,099
thin to centimeters scale when we have

691
00:38:11,609 --> 00:38:09,130
this degree of thinning we can generally

692
00:38:14,069 --> 00:38:11,619
and if we're frozen to the bed we can

693
00:38:18,720 --> 00:38:14,079
generally count on having a very long

694
00:38:22,920 --> 00:38:18,730
record and in fact we extracted from Los

695
00:38:26,940 --> 00:38:22,930
Quran just in 1993 the first glacial

696
00:38:29,700 --> 00:38:26,950
stage ice from the tropics I'm showing

697
00:38:33,950 --> 00:38:29,710
you now just the lower portion of the

698
00:38:40,410 --> 00:38:33,960
Huascar encore and we see the Delta o-18

699
00:38:44,370 --> 00:38:40,420
very negative this shift from maximum or

700
00:38:48,990 --> 00:38:44,380
most depleted to most enriched is eight

701
00:38:52,790 --> 00:38:49,000
parts per mil also a substantial

702
00:38:57,110 --> 00:38:52,800
reduction in my trait concentration

703
00:39:03,800 --> 00:38:57,120
of two or three and in an increase of

704
00:39:08,120 --> 00:39:03,810
two hundred fold indust the increase in

705
00:39:11,870 --> 00:39:08,130
dust the decrease in nitrate is very

706
00:39:13,820 --> 00:39:11,880
consistent with the climate that has

707
00:39:17,630 --> 00:39:13,830
been reconstructed the late glacial

708
00:39:20,570 --> 00:39:17,640
stage climate shown on your right based

709
00:39:23,200 --> 00:39:20,580
upon a variety of glacial geologic

710
00:39:25,670 --> 00:39:23,210
evidence and palin illogic evidence

711
00:39:29,110 --> 00:39:25,680
essentially at the height of the last

712
00:39:33,320 --> 00:39:29,120
glacial maximum deserts were twenty-five

713
00:39:36,350 --> 00:39:33,330

twenty-five percent more extensive the

714
00:39:39,140 --> 00:39:36,360
area was much drier the tropical

715
00:39:42,290 --> 00:39:39,150
rainforest which we see here in dark

716
00:39:47,150 --> 00:39:42,300
green was much less extensive much more

717
00:39:50,530 --> 00:39:47,160
Savannah and the Amazon but the Amazon

718
00:39:54,770 --> 00:39:50,540
River ran in a canyon a deep in size

719
00:40:00,590 --> 00:39:54,780
Canyon that drained the moisture out of

720
00:40:03,170 --> 00:40:00,600
this basin very effectively so the

721
00:40:05,150 --> 00:40:03,180
decrease in nitrate we think is

722
00:40:08,420 --> 00:40:05,160
associated with the reduction in

723
00:40:12,140 --> 00:40:08,430
vegetation the increase in dust is

724
00:40:16,940 --> 00:40:12,150
associated with the increased frequency

725
00:40:21,770 --> 00:40:16,950
of eolian features now let's compare the

726
00:40:25,070 --> 00:40:21,780
hot the cross quran record to similar

727
00:40:27,380 --> 00:40:25,080
records from both polar regions on the

728
00:40:31,700 --> 00:40:27,390
extreme right we have the die three

729
00:40:36,200 --> 00:40:31,710
record this is dust late glacial stage

730
00:40:40,160 --> 00:40:36,210
hi dust depleted or more negative Delta

731
00:40:43,910 --> 00:40:40,170
o-18 this is don't see this is in

732
00:40:46,700 --> 00:40:43,920
Central East Antarctica again hi dust

733
00:40:49,910 --> 00:40:46,710
for the Glacial stage and much more

734
00:40:54,950 --> 00:40:49,920
negative Delta o-18 and then on your on

735
00:40:58,010 --> 00:40:54,960
your left hi Dustin huascaran and more

736
00:41:00,640 --> 00:40:58,020
negative Delta o-18 in fact the Delta

737
00:41:03,380 --> 00:41:00,650
shift from late glacial to holocene

738
00:41:06,080 --> 00:41:03,390

conditions is eight parts per million

739
00:41:10,910 --> 00:41:06,090
huascaran compared to

740
00:41:15,440 --> 00:41:10,920
six parts per million doses per mil @

741
00:41:18,950 --> 00:41:15,450
die three just point out briefly also

742
00:41:22,430 --> 00:41:18,960
evidence for the Younger Dryas during

743
00:41:26,060 --> 00:41:22,440
the deglaciation sequence seen best here

744
00:41:29,810 --> 00:41:26,070
in Greenland there was as there the

745
00:41:32,720 --> 00:41:29,820
warming was interrupted by a return to

746
00:41:36,920 --> 00:41:32,730
near full glacial conditions for a

747
00:41:39,440 --> 00:41:36,930
matter of a thousand years or so and dr.

748
00:41:41,900 --> 00:41:39,450
McElroy will talk more about these type

749
00:41:45,200 --> 00:41:41,910
of rapid changes but I want to point out

750
00:41:48,110 --> 00:41:45,210
that the Younger Dryas is also recorded

751
00:41:50,600 --> 00:41:48,120
on this ice cap at nine degrees cell

752
00:41:53,780 --> 00:41:50,610
this is what I mean about challenging

753
00:41:56,300 --> 00:41:53,790
the existing paradigm the existing

754
00:41:58,610 --> 00:41:56,310
paradigm with regard to tropical climate

755
00:42:01,100 --> 00:41:58,620
is that the tropics don't change much

756
00:42:04,910 --> 00:42:01,110
and based on the climb a pre

757
00:42:07,160 --> 00:42:04,920
constructions the thinking was that the

758
00:42:11,390 --> 00:42:07,170
tropics during the last glacial stage

759
00:42:13,910 --> 00:42:11,400
were not substantially colder this ice

760
00:42:16,190 --> 00:42:13,920
core record along with records that are

761
00:42:18,160 --> 00:42:16,200
now emerging from corals and from some

762
00:42:20,630 --> 00:42:18,170
other pollen cores in the basin

763
00:42:22,280 --> 00:42:20,640

challenge that and suggest that

764
00:42:25,790 --> 00:42:22,290
temperatures during the last glacial

765
00:42:29,300 --> 00:42:25,800
maximum were as much as possibly five

766
00:42:31,130 --> 00:42:29,310
degrees colder we have to remember that

767
00:42:35,300 --> 00:42:31,140
the current climate models that are used

768
00:42:37,580 --> 00:42:35,310
to make future projections have been

769
00:42:41,180 --> 00:42:37,590
tested in terms of their validity

770
00:42:44,270 --> 00:42:41,190
against their ability to reproduce known

771
00:42:46,730 --> 00:42:44,280
conditions the problem is the known

772
00:42:50,300 --> 00:42:46,740
condition to which their feet were held

773
00:42:53,900 --> 00:42:50,310
to the fire were not really known that

774
00:42:56,960 --> 00:42:53,910
so these new course tell us that we have

775
00:43:00,620 --> 00:42:56,970
a lot more work to do with the climate

776
00:43:03,500 --> 00:43:00,630
modelling finally during the last two

777
00:43:06,500 --> 00:43:03,510
decades it's important to recognize that

778
00:43:09,290 --> 00:43:06,510
ice caps and glaciers outside of the

779
00:43:11,420 --> 00:43:09,300
polar region primarily have been

780
00:43:15,470 --> 00:43:11,430
diminishing or disappearing at an

781
00:43:16,880 --> 00:43:15,480
astonishing rate in the last few weeks

782
00:43:18,450 --> 00:43:16,890
if you've been listening watching

783
00:43:20,849 --> 00:43:18,460
watching on your inner

784
00:43:22,859 --> 00:43:20,859
it you'll notice there has been there

785
00:43:27,210 --> 00:43:22,869
been the reports of the increased

786
00:43:30,480 --> 00:43:27,220
frequency of icebergs from the wadell

787
00:43:32,910 --> 00:43:30,490
sea area but in reality there have been

788
00:43:37,440 --> 00:43:32,920

other observations such as the warty ice

789
00:43:40,380 --> 00:43:37,450
shelf which since about nineteen in the

790
00:43:42,960 --> 00:43:40,390
since the 1950s is now down to something

791
00:43:45,900 --> 00:43:42,970
on the order of thirty to twenty five

792
00:43:48,480 --> 00:43:45,910
percent of its size just three decades

793
00:43:51,390 --> 00:43:48,490
ago and for the first time in history

794
00:43:53,670 --> 00:43:51,400
this year ships could circumnavigate

795
00:43:56,160 --> 00:43:53,680
Ross Island because the land bridge

796
00:44:01,470 --> 00:43:56,170
connecting it to the mainland has

797
00:44:04,910 --> 00:44:01,480
disappeared the ice core record from the

798
00:44:08,010 --> 00:44:04,920
dire plateau shows us this is Delta o-18

799
00:44:10,230 --> 00:44:08,020
shows us essentially that since the 40s

800
00:44:13,200 --> 00:44:10,240
there has been a marked warming in this

801
00:44:15,270 --> 00:44:13,210
region if you might look back and say oh

802
00:44:18,030 --> 00:44:15,280
yeah but there was a warm time back then

803
00:44:21,300 --> 00:44:18,040
the difference is not the degree of the

804
00:44:26,160 --> 00:44:21,310
warmth the differences in is that warmth

805
00:44:32,520 --> 00:44:26,170
sustained and this is a 50-year warming

806
00:44:35,520 --> 00:44:32,530
period returning for the last time to

807
00:44:38,310 --> 00:44:35,530
kill kya we've had the opportunity to

808
00:44:41,700 --> 00:44:38,320
observe in this area since nineteen

809
00:44:43,859 --> 00:44:41,710
seventy-four and I have to use what used

810
00:44:47,520 --> 00:44:43,869
to be called the dirty word the M word

811
00:44:50,880 --> 00:44:47,530
that's monitoring we were always told

812
00:44:52,740 --> 00:44:50,890
fuel in the I scoring business that we

813
00:44:55,020 --> 00:44:52,750

don't monitor we just go out and get

814
00:44:57,990 --> 00:44:55,030
records what we have found is that

815
00:45:00,089 --> 00:44:58,000
monitoring is critical just like the ice

816
00:45:03,480 --> 00:45:00,099
course that provide this long-term

817
00:45:06,089 --> 00:45:03,490
history we need to be monitoring now we

818
00:45:08,010 --> 00:45:06,099
need to start these records whether

819
00:45:09,630 --> 00:45:08,020
they're people will say yeah but if we

820
00:45:11,670 --> 00:45:09,640
start a satellite record we're only

821
00:45:13,440 --> 00:45:11,680
going to have in 20 years we're just

822
00:45:15,359 --> 00:45:13,450
going to have 20 years but that's 20

823
00:45:18,150 --> 00:45:15,369
more years then you would have if you

824
00:45:21,690 --> 00:45:18,160
don't start the program and I'll just

825
00:45:26,400 --> 00:45:21,700
show you the value of monitoring on kal

826
00:45:28,380 --> 00:45:26,410
kya in 1976 we drilled the core here at

827
00:45:32,479 --> 00:45:28,390
the summit and you can see the beautiful

828
00:45:36,420 --> 00:45:32,489
preservation of oxygen isotopic ratios

829
00:45:38,489 --> 00:45:36,430
at the same site in 1991 we drilled a

830
00:45:40,680 --> 00:45:38,499
core and you can see that record is

831
00:45:43,289 --> 00:45:40,690
obliterated it's obliterated by the

832
00:45:45,779 --> 00:45:43,299
percolation of meltwater if we were

833
00:45:48,239 --> 00:45:45,789
looking at the Cal kya ice cap today and

834
00:45:51,329 --> 00:45:48,249
trying to determine whether it had the

835
00:45:56,789 --> 00:45:51,339
potential for a long-term climate record

836
00:45:59,279 --> 00:45:56,799
we would pass it up this is the quarry

837
00:46:02,880 --> 00:45:59,289
Kahless glacier it's the largest outlet

838
00:46:05,430 --> 00:46:02,890

glacier on kal kya and we have been able

839
00:46:08,339 --> 00:46:05,440
to get terrestrial photography that

840
00:46:15,809 --> 00:46:08,349
shows the retreat of that outlet glacier

841
00:46:21,960 --> 00:46:15,819
since 1963 6880 391 more importantly

842
00:46:24,390 --> 00:46:21,970
this graph is the rate of retreat from

843
00:46:26,670 --> 00:46:24,400
nineteen sixty three to nineteen seventy

844
00:46:30,229 --> 00:46:26,680
eight it retreated at a rate of four

845
00:46:35,249 --> 00:46:30,239
meters a year then seven meters a year

846
00:46:40,769 --> 00:46:35,259
and since 1978 I'm sorry since 1983 it's

847
00:46:43,979 --> 00:46:40,779
retreated 14 meters a year finally we

848
00:46:46,109 --> 00:46:43,989
just have basic observations this

849
00:46:49,559 --> 00:46:46,119
Boulder is about the size of this stage

850
00:46:51,749 --> 00:46:49,569
and this ice cliff which is vertical

851
00:46:55,289 --> 00:46:51,759
this is kal kya again I'm coming back

852
00:46:57,719 --> 00:46:55,299
now to that vertical margin is about 20

853
00:47:02,579 --> 00:46:57,729
meters high and this picture was taken

854
00:47:08,719 --> 00:47:02,589
in 1977 this is one year later in

855
00:47:18,269 --> 00:47:08,729
nineteen seventy eight nineteen seventy

856
00:47:23,130 --> 00:47:18,279
1983 1989 this is the boulder now this

857
00:47:26,249 --> 00:47:23,140
is the margin and in 1993 this is the

858
00:47:29,190 --> 00:47:26,259
boulder this is the margin and it's 20

859
00:47:31,709 --> 00:47:29,200
centimeters high this is happening

860
00:47:34,589 --> 00:47:31,719
around the world in the tropics and

861
00:47:39,719 --> 00:47:34,599
subtropics the Lewis glacier has lost

862
00:47:44,849 --> 00:47:39,729
forty percent of its of its mass in the

863
00:47:46,260 --> 00:47:44,859

last 25 years in the ruined zorry the

864
00:47:49,680 --> 00:47:46,270
speak glacier

865
00:47:51,840 --> 00:47:49,690
they're all disappearing the sad part is

866
00:47:53,520 --> 00:47:51,850
not only is there an omen here that

867
00:47:55,500 --> 00:47:53,530
something is different that these ice

868
00:47:58,620 --> 00:47:55,510
masses that have lasted for centuries

869
00:48:01,230 --> 00:47:58,630
are going away that should concern us

870
00:48:05,570 --> 00:48:01,240
but with them they're taking these very

871
00:48:08,540 --> 00:48:05,580
valuable archives so I hope that I have