
1
2
3

1
00:00:11,089 --> 00:00:08,839
from the unique vantage point of the

2
00:00:14,320 --> 00:00:11,099
space shuttle Atlantis we can see the

3
00:00:17,150 --> 00:00:14,330
separation of two diverse environments

4
00:00:17,720 --> 00:00:17,160
all around us is the endless vacuum of

5
00:00:19,970 --> 00:00:17,730
space

6
00:00:22,279 --> 00:00:19,980
avoid where humans cannot survive

7
00:00:25,880 --> 00:00:22,289
without elaborate life-support systems

8
00:00:27,740 --> 00:00:25,890
and below us like a blue and white oasis

9
00:00:32,020 --> 00:00:27,750
in the middle of a lifeless desert is

10
00:00:34,100 --> 00:00:32,030
earth a place of abundant life

11
00:00:36,740 --> 00:00:34,110
separating these two extreme

12
00:00:40,010 --> 00:00:36,750
environments is a thin and fragile shell

13
00:00:42,530 --> 00:00:40,020

of gases we call our atmosphere in

14
00:00:46,760 --> 00:00:42,540
thickness the atmosphere is to the earth

15
00:00:48,950 --> 00:00:46,770
like the fuzz is to a tennis ball but in

16
00:00:50,869 --> 00:00:48,960
spite of its relative thinness the

17
00:00:53,990 --> 00:00:50,879
atmosphere is vitally important to life

18
00:00:57,110 --> 00:00:54,000
on earth it's the atmosphere that gives

19
00:01:00,430 --> 00:00:57,120
us the air we breathe it regulates our

20
00:01:03,319 --> 00:01:00,440
climate to make the earth habitable and

21
00:01:05,690 --> 00:01:03,329
it's a filter that screens out much of

22
00:01:07,580 --> 00:01:05,700
the sun's harmful radiation while

23
00:01:10,490 --> 00:01:07,590
allowing the radiation needed for life

24
00:01:13,219 --> 00:01:10,500
to pass through it should come as no

25
00:01:15,410 --> 00:01:13,229
surprise that life as we know it would

26
00:01:18,710 --> 00:01:15,420
cease to exist if our atmosphere didn't

27
00:01:21,200 --> 00:01:18,720
perform its unique functions but

28
00:01:22,340 --> 00:01:21,210
recently scientists have begun to detect

29
00:01:24,580 --> 00:01:22,350
that our atmosphere has been

30
00:01:26,960 --> 00:01:24,590
experiencing mysterious new changes

31
00:01:29,420 --> 00:01:26,970
changes that appear to be the result of

32
00:01:31,399 --> 00:01:29,430
human activity changes that could

33
00:01:34,850 --> 00:01:31,409
ultimately affect our lives in a major

34
00:01:36,710 --> 00:01:34,860
way many of you may have heard about

35
00:01:39,620 --> 00:01:36,720
ozone depletion the greenhouse effect

36
00:01:40,969 --> 00:01:39,630
and global warming all of these are

37
00:01:43,730 --> 00:01:40,979
related to the changes that are taking

38
00:01:45,770 --> 00:01:43,740

place in our atmosphere but do any of

39
00:01:48,190 --> 00:01:45,780
you know who or what is causing the

40
00:01:50,350 --> 00:01:48,200
changes

41
00:01:52,469 --> 00:01:50,360
as a scientist I've always considered

42
00:01:54,069 --> 00:01:52,479
myself a detective of sorts

43
00:01:55,990 --> 00:01:54,079
investigating the earth and its

44
00:01:57,760 --> 00:01:56,000
environment asking important questions

45
00:02:01,749 --> 00:01:57,770
that hopefully will lead to practical

46
00:03:05,510 --> 00:02:01,759
solutions join me now and let's see if

47
00:03:11,700 --> 00:03:08,220
let's begin our investigation by finding

48
00:03:13,530 --> 00:03:11,710
out what's happening to the ozone first

49
00:03:16,050 --> 00:03:13,540
we'll need to ask a few questions to get

50
00:03:19,890 --> 00:03:16,060
some background for starters what is

51
00:03:23,340 --> 00:03:19,900
ozone ozone is oxygen but not the kind

52
00:03:25,500 --> 00:03:23,350
we normally think of a regular oxygen

53
00:03:28,980 --> 00:03:25,510
molecule is formed by two oxygen atoms

54
00:03:31,530 --> 00:03:28,990
that are bonded together but ozone

55
00:03:35,130 --> 00:03:31,540
molecules are different they have three

56
00:03:36,750 --> 00:03:35,140
oxygen atoms bonded together ozone can

57
00:03:39,320 --> 00:03:36,760
be made in a laboratory on the ground

58
00:03:41,910 --> 00:03:39,330
where we can study its characteristics

59
00:03:44,670 --> 00:03:41,920
ozone is also made naturally in the

60
00:03:46,320 --> 00:03:44,680
upper atmosphere there ultraviolet light

61
00:03:48,449 --> 00:03:46,330
from the Sun breaks the bond in

62
00:03:51,150 --> 00:03:48,459
molecular oxygen to form two separate

63
00:03:54,690 --> 00:03:51,160

atoms these atoms may then join with

64
00:03:58,530 --> 00:03:54,700
other molecules to form ozone why is

65
00:04:00,690 --> 00:03:58,540
ozone so special well without ozone in

66
00:04:03,210 --> 00:04:00,700
our atmosphere I would probably need a

67
00:04:06,090 --> 00:04:03,220
sunscreen protection factor of five

68
00:04:09,990 --> 00:04:06,100
hundred and probably even that would not

69
00:04:12,720 --> 00:04:10,000
be enough you see ozone blocks

70
00:04:14,970 --> 00:04:12,730
ultraviolet radiation up in the

71
00:04:18,270 --> 00:04:14,980
stratosphere ozone forms a very thin

72
00:04:22,650 --> 00:04:18,280
layer so thin that for every 1 million

73
00:04:23,850 --> 00:04:22,660
gas molecules only 10 our ozone but even

74
00:04:25,980 --> 00:04:23,860
as thin as it is

75
00:04:31,680 --> 00:04:25,990
the ozone layer is able to screen out

76
00:04:37,990 --> 00:04:34,120
just having to cut back on the amount of

77
00:04:40,420 --> 00:04:38,000
sunscreen be happy to buy ozone is

78
00:04:42,550 --> 00:04:40,430
important to all life on earth because

79
00:04:44,230 --> 00:04:42,560
without it scientists believe cases of

80
00:04:47,860 --> 00:04:44,240
skin cancer and eye cataracts would

81
00:04:51,540 --> 00:04:47,870
increase and since sunscreen only helps

82
00:04:54,310 --> 00:04:51,550
humans animals would be unprotected

83
00:04:56,170 --> 00:04:54,320
crops and plant life would also be

84
00:04:59,770 --> 00:04:56,180
affected and that would upset the

85
00:05:02,020 --> 00:04:59,780
Earth's entire ecological system in fact

86
00:05:03,580 --> 00:05:02,030
the diversity of life as we know it

87
00:05:05,890 --> 00:05:03,590
would change drastically

88
00:05:09,190 --> 00:05:05,900

if ozone disappeared from the atmosphere

89
00:05:11,890 --> 00:05:09,200
by looking at the atmosphere of home

90
00:05:13,360 --> 00:05:11,900
space with just our eyes we can't tell

91
00:05:16,480 --> 00:05:13,370
if anything is happening to the ozone

92
00:05:18,340 --> 00:05:16,490
layer or not but scientific instruments

93
00:05:21,880 --> 00:05:18,350
carried on weather balloons sounding

94
00:05:23,440 --> 00:05:21,890
rockets and satellites show us revealing

95
00:05:26,470 --> 00:05:23,450
evidence that ozone levels are

96
00:05:28,870 --> 00:05:26,480
decreasing over much of the earth from

97
00:05:31,330 --> 00:05:28,880
September through November ozone levels

98
00:05:34,270 --> 00:05:31,340
decrease over Antarctica this is what's

99
00:05:36,610 --> 00:05:34,280
called the ozone hole the ozone hole

100
00:05:38,680 --> 00:05:36,620
allows more ultraviolet radiation to

101
00:05:41,920 --> 00:05:38,690
reach Antarctica than would otherwise do

102
00:05:44,290 --> 00:05:41,930
so but changes in ozone concentration

103
00:05:47,710 --> 00:05:44,300
are more complex than just the

104
00:05:49,870 --> 00:05:47,720
appearance of seasonal holes so now we

105
00:05:51,850 --> 00:05:49,880
know over many parts of the world are

106
00:05:54,700 --> 00:05:51,860
decreasing and we know some of the

107
00:05:56,530 --> 00:05:54,710
chemicals that play in this game but a

108
00:05:58,540 --> 00:05:56,540
good detective always has to look beyond

109
00:06:04,120 --> 00:05:58,550
the obvious we have to ask ourselves

110
00:06:06,070 --> 00:06:04,130
where do these chemicals come from two

111
00:06:08,620 --> 00:06:06,080
of the suspects are the chemical

112
00:06:11,530 --> 00:06:08,630
compounds chlorofluorocarbons also known

113
00:06:14,620 --> 00:06:11,540

as CFCs and oxides of nitrogen which

114
00:06:17,050 --> 00:06:14,630
have many faces here's why we suspect

115
00:06:19,240 --> 00:06:17,060
them in the upper atmosphere these

116
00:06:21,130 --> 00:06:19,250
compounds react with sunlight and are

117
00:06:24,250 --> 00:06:21,140
broken down into smaller parts

118
00:06:27,970 --> 00:06:24,260
the CFCs give off chlorine atoms while

119
00:06:29,800 --> 00:06:27,980
nitrogen oxides form nitric oxide there

120
00:06:31,990 --> 00:06:29,810
they are joined by other chemicals

121
00:06:32,990 --> 00:06:32,000
containing hydrogen sulfur and other

122
00:06:35,760 --> 00:06:33,000
atoms

123
00:06:38,550 --> 00:06:35,770
when these chemicals encounter ozone a

124
00:06:42,330 --> 00:06:38,560
reaction occurs that strips away an atom

125
00:06:44,790 --> 00:06:42,340
of oxygen from the ozone molecule the

126
00:06:47,700 --> 00:06:44,800
products of these reactions react with

127
00:06:49,920 --> 00:06:47,710
ozone also just a small amount of

128
00:06:52,880 --> 00:06:49,930
chlorine and nitric oxide can create a

129
00:06:55,440 --> 00:06:52,890
cycle that destroys many ozone molecules

130
00:06:57,210 --> 00:06:55,450
it looks like we may have some of the

131
00:06:58,890 --> 00:06:57,220
key players responsible for the ozone

132
00:07:02,010 --> 00:06:58,900
destruction but there are a lot more

133
00:07:04,470 --> 00:07:02,020
detail to be worked out a good detective

134
00:07:06,270 --> 00:07:04,480
I always looks beyond the obvious we've

135
00:07:09,300 --> 00:07:06,280
got to ask ourselves where are these

136
00:07:13,200 --> 00:07:09,310
chemicals coming from they come from

137
00:07:14,970 --> 00:07:13,210
many sources hydrogen compounds come

138
00:07:16,680 --> 00:07:14,980

from the gas methane that's formed by

139
00:07:18,290 --> 00:07:16,690
agricultural activities such as rice

140
00:07:20,970 --> 00:07:18,300
production and the cattle industry

141
00:07:24,650 --> 00:07:20,980
decaying vegetation and swamps also

142
00:07:29,400 --> 00:07:24,660
produces methane chlorofluorocarbons or

143
00:07:31,140 --> 00:07:29,410
CFCs are made by humans what form of

144
00:07:33,060 --> 00:07:31,150
this chemical is the gas used in our

145
00:07:37,140 --> 00:07:33,070
refrigerators and air-conditioning units

146
00:07:39,090 --> 00:07:37,150
to chill the air it's also used to blow

147
00:07:43,890 --> 00:07:39,100
insulating firm and clean electrical

148
00:07:46,860 --> 00:07:43,900
components nitrogen compounds come from

149
00:07:49,410 --> 00:07:46,870
many sources exhaust emission from

150
00:07:53,130 --> 00:07:49,420
high-flying supersonic aircraft is only

151
00:07:55,050 --> 00:07:53,140
one of them nitrogen is also released

152
00:07:59,210 --> 00:07:55,060
into the atmosphere during lightning

153
00:08:02,070 --> 00:07:59,220
storms in tropical regions many chemical

154
00:08:04,590 --> 00:08:02,080
fertilizers that we use to grow our food

155
00:08:07,920 --> 00:08:04,600
are nitrogen based and they lead to

156
00:08:12,150 --> 00:08:07,930
increased releases of nitrous oxide into

157
00:08:14,490 --> 00:08:12,160
the atmosphere too so now we know that

158
00:08:17,430 --> 00:08:14,500
mother nature and humans both contribute

159
00:08:18,750 --> 00:08:17,440
to the decreasing ozone but does that

160
00:08:23,100 --> 00:08:18,760
mean that one of them is more

161
00:08:25,680 --> 00:08:23,110
responsible than the other well we don't

162
00:08:27,750 --> 00:08:25,690
know for certain that part of the

163
00:08:31,230 --> 00:08:27,760

mystery requires more investigation and

164
00:08:33,150 --> 00:08:31,240
that's why we're here during this

165
00:08:34,770 --> 00:08:33,160
spaceflight we are observing the

166
00:08:37,350 --> 00:08:34,780
atmosphere in the Sun with several

167
00:08:38,969 --> 00:08:37,360
sophisticated instruments the data we

168
00:08:40,380 --> 00:08:38,979
gather will not only improve our

169
00:08:41,969 --> 00:08:40,390
knowledge of the amounts of ozone

170
00:08:44,400 --> 00:08:41,979
depleting chemicals found in the

171
00:08:45,269 --> 00:08:44,410
atmosphere it will also help us to

172
00:08:52,290 --> 00:08:45,279
better understand

173
00:08:56,250 --> 00:08:54,480
when the facts are all in we'll have a

174
00:08:57,840 --> 00:08:56,260
better understanding of the distribution

175
00:09:01,470 --> 00:08:57,850
of ozone depleting chemicals in the

176
00:09:03,210 --> 00:09:01,480
atmosphere now let's turn our attention

177
00:09:11,010 --> 00:09:03,220
to another mystery of the changing

178
00:09:14,460 --> 00:09:11,020
atmosphere below you know summers here

179
00:09:16,160 --> 00:09:14,470
in Houston can be pretty hot it's hard

180
00:09:18,900 --> 00:09:16,170
to imagine they could get much hotter

181
00:09:23,580 --> 00:09:18,910
but some scientists say it's actually

182
00:09:25,560 --> 00:09:23,590
happening actually Earth's climate has

183
00:09:29,760 --> 00:09:25,570
changed many times over millions of

184
00:09:32,970 --> 00:09:29,770
years we've had ice ages and we've had

185
00:09:34,470 --> 00:09:32,980
warmer periods that's because several

186
00:09:37,980 --> 00:09:34,480
factors that affect the climate of the

187
00:09:40,110 --> 00:09:37,990
earth vary over tonight one of these is

188
00:09:42,210 --> 00:09:40,120

the concentration of carbon dioxide a

189
00:09:46,160 --> 00:09:42,220
gas present in the atmosphere in very

190
00:09:48,990 --> 00:09:46,170
small quantities here's how it works

191
00:09:52,890 --> 00:09:49,000
picture a primeval setting with lots of

192
00:09:54,810 --> 00:09:52,900
volcanic activity as the volcanoes erupt

193
00:09:58,230 --> 00:09:54,820
they spew large amounts of carbon

194
00:10:01,310 --> 00:09:58,240
dioxide into the atmosphere carbon

195
00:10:04,170 --> 00:10:01,320
dioxide is what we call a greenhouse gas

196
00:10:06,450 --> 00:10:04,180
that's because it blankets the earth and

197
00:10:10,980 --> 00:10:06,460
traps heat much the same as a greenhouse

198
00:10:12,960 --> 00:10:10,990
does in a greenhouse incoming radiation

199
00:10:15,970 --> 00:10:12,970
from the Sun passes through the

200
00:10:18,740 --> 00:10:15,980
translucent roof unhindered

201
00:10:21,460 --> 00:10:18,750
but the heat radiated back from the

202
00:10:24,320 --> 00:10:21,470
earth is trapped by the glass

203
00:10:27,019 --> 00:10:24,330
this trapped heat causes the temperature

204
00:10:29,269 --> 00:10:27,029
in the greenhouse to rise the same thing

205
00:10:33,140 --> 00:10:29,279
happens in the atmosphere if carbon

206
00:10:35,690 --> 00:10:33,150
dioxide increases heat becomes trapped

207
00:10:44,700 --> 00:10:35,700
under the atmospheric blanket and global

208
00:10:48,389 --> 00:10:46,740
so what's a few degrees the earth's

209
00:10:50,960 --> 00:10:48,399
temperature changes every day when the

210
00:10:53,340 --> 00:10:50,970
sun goes down

211
00:10:55,110 --> 00:10:53,350
well the slightly warmer global

212
00:10:58,110 --> 00:10:55,120
temperatures can cause other changes to

213
00:11:00,180 --> 00:10:58,120

happen polar ice caps and mountain

214
00:11:03,900 --> 00:11:00,190
glaciers begin to melt adding fresh

215
00:11:06,990 --> 00:11:03,910
water to the oceans and ocean water

216
00:11:09,389 --> 00:11:07,000
itself expands as it warms together

217
00:11:13,050 --> 00:11:09,399
these two changes can cause ocean levels

218
00:11:14,850 --> 00:11:13,060
to rise flooding lowlands warmer

219
00:11:16,740 --> 00:11:14,860
temperatures along with sufficient

220
00:11:19,710 --> 00:11:16,750
rainfall also mean that more green

221
00:11:21,630 --> 00:11:19,720
plants grow but to some extent ocean

222
00:11:24,360 --> 00:11:21,640
water and vegetation both naturally

223
00:11:26,220 --> 00:11:24,370
absorb carbon dioxide from the air so

224
00:11:28,590 --> 00:11:26,230
with more ocean surface and more

225
00:11:31,590 --> 00:11:28,600
vegetation more carbon dioxide is

226
00:11:33,540 --> 00:11:31,600
removed from the atmosphere eventually

227
00:11:35,070 --> 00:11:33,550
enough carbon dioxide may be removed

228
00:11:37,260 --> 00:11:35,080
from the atmosphere so that the

229
00:11:42,180 --> 00:11:37,270
greenhouse effect begins to diminish and

230
00:11:44,040 --> 00:11:42,190
the earth begins to cool again of course

231
00:11:46,410 --> 00:11:44,050
climate change is not that simple there

232
00:11:48,030 --> 00:11:46,420
are a lot of other factors too some of

233
00:11:51,110 --> 00:11:48,040
the same chemicals that are hurting the

234
00:11:53,579 --> 00:11:51,120
ozone layer contribute to global warming

235
00:11:59,850 --> 00:11:53,589
also things like photosynthesis

236
00:12:02,699 --> 00:11:59,860
respiration ocean currents forest fires

237
00:12:06,690 --> 00:12:02,709
and fluctuations in the amount of energy

238
00:12:08,790 --> 00:12:06,700

generated by the Sun so if the earth's

239
00:12:12,810 --> 00:12:08,800
temperature varies a few degrees what's

240
00:12:15,000 --> 00:12:12,820
the big mystery measurements of co2 and

241
00:12:16,860 --> 00:12:15,010
air samples trapped in ice indicate that

242
00:12:19,079 --> 00:12:16,870
levels of carbon dioxide are increasing

243
00:12:21,630 --> 00:12:19,089
our planet appears to be warming more

244
00:12:23,820 --> 00:12:21,640
than normal this is another mystery of

245
00:12:26,100 --> 00:12:23,830
where and who where is this excess

246
00:12:30,060 --> 00:12:26,110
carbon dioxide coming from and who or

247
00:12:31,680 --> 00:12:30,070
what is responsible for it parent space

248
00:12:35,639 --> 00:12:31,690
we can see some natural sources of

249
00:12:40,980 --> 00:12:40,300
volcanoes and naturally caused forest

250
00:12:43,449 --> 00:12:40,990
fires

251
00:12:47,019 --> 00:12:43,459
but many human activities are also

252
00:12:49,480 --> 00:12:47,029
releasing carbon dioxide for more than

253
00:12:50,819 --> 00:12:49,490
100 years the fossil fuel burning

254
00:12:53,620 --> 00:12:50,829
machines of the Industrial Revolution

255
00:12:55,059 --> 00:12:53,630
have dumped millions of tons of carbon

256
00:12:57,699 --> 00:12:55,069
dioxide into the atmosphere

257
00:12:59,199 --> 00:12:57,709
at the same time the harvesting of

258
00:13:01,889 --> 00:12:59,209
forests and clearing land for

259
00:13:04,360 --> 00:13:01,899
cultivation is reducing vegetation color

260
00:13:06,430 --> 00:13:04,370
vegetation uses carbon dioxide for

261
00:13:09,449 --> 00:13:06,440
growth and in doing so tends to limit

262
00:13:12,129 --> 00:13:09,459
atmospheric increases of carbon dioxide

263
00:13:14,259 --> 00:13:12,139

so once again we fight both nature and

264
00:13:17,530 --> 00:13:14,269
humans are causing our atmosphere to

265
00:13:20,800 --> 00:13:17,540
change these relatively rapid changes

266
00:13:25,960 --> 00:13:20,810
leading to a major warming that part

267
00:13:28,809 --> 00:13:25,970
investigation is still underway in 1991

268
00:13:31,120 --> 00:13:28,819
the upper atmospheric research satellite

269
00:13:34,180 --> 00:13:31,130
or urs was launched from the space

270
00:13:36,460 --> 00:13:34,190
shuttle Discovery you ours is using 10

271
00:13:39,160 --> 00:13:36,470
highly sophisticated sensors to conduct

272
00:13:41,050 --> 00:13:39,170
a long-term study of the atmosphere it

273
00:13:42,850 --> 00:13:41,060
will compile the most complete data ever

274
00:13:46,360 --> 00:13:42,860
collected on energy input from the Sun

275
00:13:47,889 --> 00:13:46,370
winds and atmospheric composition this

276
00:13:49,660 --> 00:13:47,899
information will add to the clues we

277
00:13:53,110 --> 00:13:49,670
have for solving the mystery of ozone

278
00:13:54,670 --> 00:13:53,120
depletion and global warming but another

279
00:13:58,300 --> 00:13:54,680
part of the investigation is happening

280
00:14:00,490 --> 00:13:58,310
right here on space shuttle Atlantis our

281
00:14:02,350 --> 00:14:00,500
atmospheric laboratory for applications

282
00:14:04,410 --> 00:14:02,360
and science is gathering important

283
00:14:06,970 --> 00:14:04,420
information about the atmosphere such as

284
00:14:08,500 --> 00:14:06,980
what trace gases and chemicals are

285
00:14:12,100 --> 00:14:08,510
present in the atmosphere and in what

286
00:14:15,160 --> 00:14:12,110
quantities and what is the ultraviolet

287
00:14:18,040 --> 00:14:15,170
radiation output of the Sun the URS

288
00:14:19,870 --> 00:14:18,050

satellite and this mission are the start

289
00:14:21,730 --> 00:14:19,880
of a long term investigation of the

290
00:14:24,939 --> 00:14:21,740
interaction of the sun's energy with

291
00:14:26,319 --> 00:14:24,949
Earth's atmosphere the goal is to better

292
00:14:28,059 --> 00:14:26,329
understand how chemicals in the

293
00:14:30,100 --> 00:14:28,069
atmosphere reacting with the sun's

294
00:14:32,270 --> 00:14:30,110
changing energy levels are affecting our

295
00:14:34,680 --> 00:14:32,280
environment

296
00:14:36,510 --> 00:14:34,690
there are obviously a lot more questions

297
00:14:38,910 --> 00:14:36,520
that need to be asked and answered

298
00:14:41,480 --> 00:14:38,920
before we can completely solve the

299
00:14:43,950 --> 00:14:41,490
mysteries of our changing atmosphere

300
00:14:45,630 --> 00:14:43,960
it's going to take far more than a

301
00:14:48,210 --> 00:14:45,640
single satellite or a single shuttle

302
00:14:50,160 --> 00:14:48,220
mission to solve this puzzle this

303
00:14:53,520 --> 00:14:50,170
investigation is going to take long term

304
00:14:54,900 --> 00:14:53,530
study by many dedicated scientists some

305
00:14:56,820 --> 00:14:54,910
of the people who ultimately will

306
00:14:58,920 --> 00:14:56,830
unravel all these clues inside the

307
00:15:02,040 --> 00:14:58,930
mystery are probably sitting right