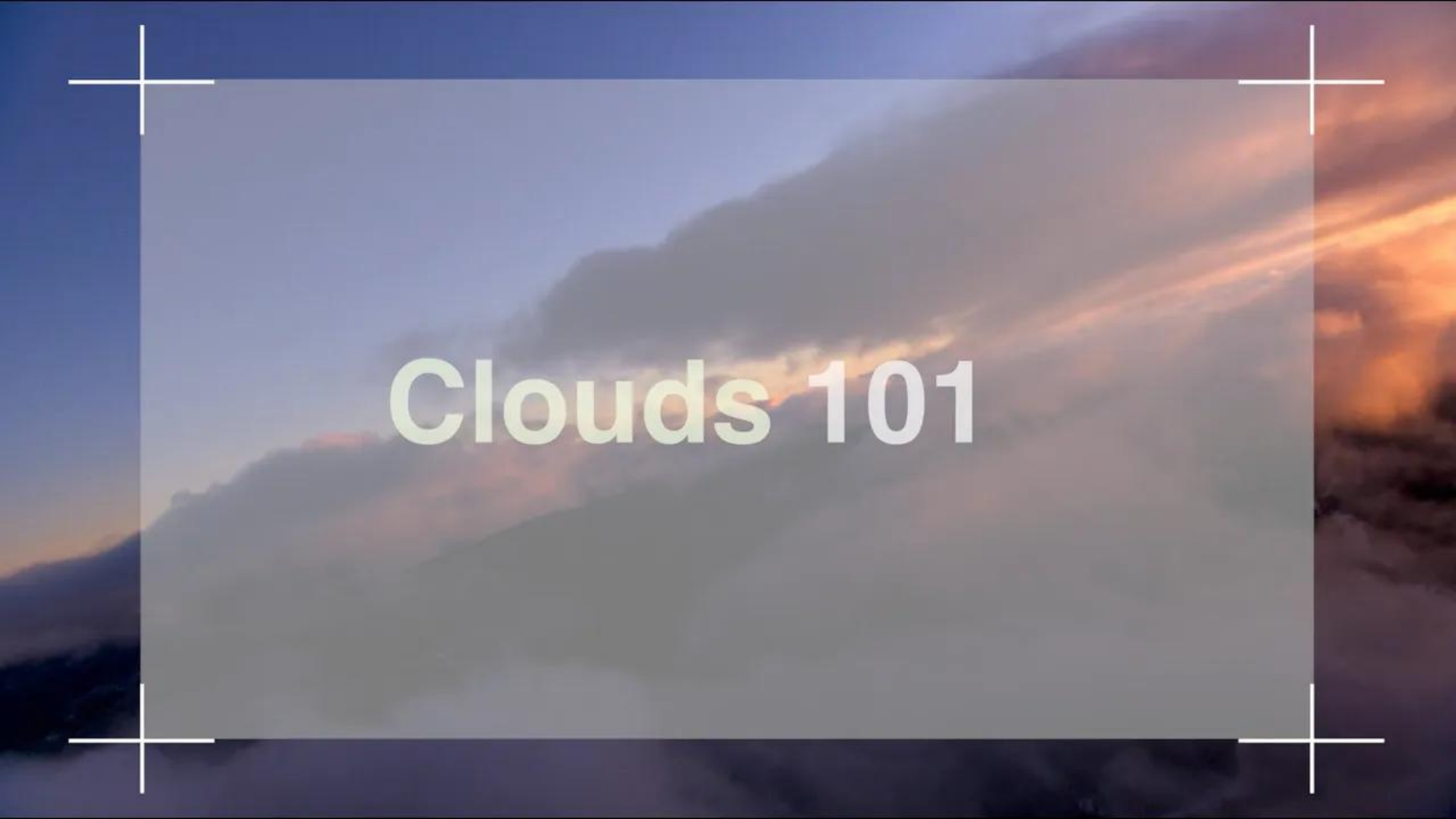
Clouds 101

1
00:00:08,210 --> 00:00:05,630
clouds they seem so simple when they

2
00:00:10,310 --> 00:00:08,220
appear darker we pack an umbrella when

3
00:00:11,870 --> 00:00:10,320
they're nowhere in sight we pack extra

4
00:00:14,509 --> 00:00:11,880
sunscreen

5
00:00:16,970 --> 00:00:14,519
either way we look to clouds for more

6
00:00:19,250 --> 00:00:16,980
information than you might realize but

7
00:00:21,189 --> 00:00:19,260
for all that they can tell us they

8
00:00:23,390 --> 00:00:21,199
actually remain quite mysterious

9
00:00:26,509 --> 00:00:23,400
especially when it comes to how they

10
00:00:28,730 --> 00:00:26,519
impact the climate the question is

11
00:00:30,830 --> 00:00:28,740
because clouds are produced by the

12
00:00:34,310 --> 00:00:30,840
climate how will a changing climate

13
00:00:36,830 --> 00:00:34,320

impact clouds and conversely clouds have

14
00:00:38,690 --> 00:00:36,840
an impact on our climate so how will

15
00:00:43,389 --> 00:00:38,700
changing clouds affect a change in

16
00:00:46,610 --> 00:00:43,399
climate welcome to clouds 101

17
00:00:48,970 --> 00:00:46,620
like all good Mysteries this one begins

18
00:00:51,709 --> 00:00:48,980
with a sophisticated scientific concept

19
00:00:55,790 --> 00:00:51,719
Earth's radiation budget

20
00:00:58,130 --> 00:00:55,800
delicate balance between the sun's

21
00:01:00,229 --> 00:00:58,140
radiant energy that reaches Earth and

22
00:01:03,170 --> 00:01:00,239
the radiant energy that flows from Earth

23
00:01:05,630 --> 00:01:03,180
back out to space about 30 percent of

24
00:01:07,310 --> 00:01:05,640
the sun's incoming energy essentially

25
00:01:10,010 --> 00:01:07,320
the light and heat we're familiar with

26
00:01:11,870 --> 00:01:10,020
is reflected back to space by gaseous

27
00:01:14,630 --> 00:01:11,880
molecules in the atmosphere tiny

28
00:01:18,109 --> 00:01:14,640
particles called aerosols land snow and

29
00:01:20,570 --> 00:01:18,119
ice surfaces and by clouds the remaining

30
00:01:22,850 --> 00:01:20,580
energy from the Sun roughly 70 percent

31
00:01:25,310 --> 00:01:22,860
is absorbed by the planet

32
00:01:26,929 --> 00:01:25,320
most of this absorbed energy heats up

33
00:01:28,730 --> 00:01:26,939
Earth's surface while the rest is

34
00:01:32,030 --> 00:01:28,740
absorbed in the atmosphere by gas

35
00:01:34,370 --> 00:01:32,040
molecules clouds and aerosols

36
00:01:36,710 --> 00:01:34,380
so heat can be both absorbed and

37
00:01:37,910 --> 00:01:36,720
reflected by clouds we'll come back to

38
00:01:40,789 --> 00:01:37,920

this later

39
00:01:43,069 --> 00:01:40,799
heat is also separately emitted by Earth

40
00:01:45,649 --> 00:01:43,079
into space in the form of thermal

41
00:01:47,390 --> 00:01:45,659
infrared radiation which is the kind of

42
00:01:49,010 --> 00:01:47,400
heat humans can only see through night

43
00:01:51,050 --> 00:01:49,020
vision goggles

44
00:01:53,810 --> 00:01:51,060
for Earth's temperature to remain

45
00:01:56,210 --> 00:01:53,820
constant the absorbed solar radiation

46
00:01:59,149 --> 00:01:56,220
and outgoing thermal infrared radiation

47
00:02:01,190 --> 00:01:59,159
must balance one another if the Earth

48
00:02:03,950 --> 00:02:01,200
system is changed either through natural

49
00:02:06,050 --> 00:02:03,960
phenomena like volcanic activity or

50
00:02:08,870 --> 00:02:06,060
through unnatural phenomena like humans

51
00:02:11,570 --> 00:02:08,880
burning fossil fuels an imbalance in

52
00:02:13,070 --> 00:02:11,580
Earth's radiation budget occurs and as a

53
00:02:15,890 --> 00:02:13,080
result the Earth's temperature

54
00:02:18,170 --> 00:02:15,900
eventually increases or decreases to

55
00:02:21,110 --> 00:02:18,180
restore an energy balance

56
00:02:23,089 --> 00:02:21,120
in recent decades satellite and surface

57
00:02:25,070 --> 00:02:23,099
measurements clearly show an energy

58
00:02:28,790 --> 00:02:25,080
imbalance taking place that's been

59
00:02:30,830 --> 00:02:28,800
increasing over the past 150 years the

60
00:02:33,290 --> 00:02:30,840
large rise in carbon dioxide emissions

61
00:02:35,390 --> 00:02:33,300
which accumulate in the atmosphere has

62
00:02:37,550 --> 00:02:35,400
created an enhanced greenhouse effect

63
00:02:40,309 --> 00:02:37,560

this means that energy from the Sun

64
00:02:42,589 --> 00:02:40,319
still easily reaches Earth but Earth's

65
00:02:45,410 --> 00:02:42,599
thermal infrared radiation has a harder

66
00:02:47,869 --> 00:02:45,420
time getting out into space this has

67
00:02:50,990 --> 00:02:47,879
caused a decrease in how much heat earth

68
00:02:52,850 --> 00:02:51,000
sheds consequently we have observed a

69
00:02:55,070 --> 00:02:52,860
rise in Earth's Global mean surface

70
00:02:58,309 --> 00:02:55,080
temperature an increased melting of snow

71
00:03:01,070 --> 00:02:58,319
and sea ice sea level rise and more

72
00:03:03,410 --> 00:03:01,080
extreme weather events so that brings us

73
00:03:05,210 --> 00:03:03,420
back to the mystery of clouds long-term

74
00:03:08,089 --> 00:03:05,220
effects on climate

75
00:03:11,030 --> 00:03:08,099
here's what we know so far clouds impact

76
00:03:13,309 --> 00:03:11,040
the radiation budget in two ways by

77
00:03:15,350 --> 00:03:13,319
reflecting solar radiation back to space

78
00:03:16,610 --> 00:03:15,360
which leads to a cooling effect on the

79
00:03:19,250 --> 00:03:16,620
climate

80
00:03:20,750 --> 00:03:19,260
and by absorbing heat emitted from below

81
00:03:22,670 --> 00:03:20,760
the clouds that would have otherwise

82
00:03:25,270 --> 00:03:22,680
escaped to space if the clouds weren't

83
00:03:28,009 --> 00:03:25,280
present leading to a warming effect

84
00:03:30,050 --> 00:03:28,019
which of these effects dominates in any

85
00:03:33,050 --> 00:03:30,060
given location depends upon the cloud

86
00:03:34,990 --> 00:03:33,060
type high altitude clouds are typically

87
00:03:37,790 --> 00:03:35,000
thinner and colder than low clouds

88
00:03:39,170 --> 00:03:37,800

allowing for more solar radiation to

89
00:03:42,110 --> 00:03:39,180
pass through them and reach Earth's

90
00:03:44,330 --> 00:03:42,120
surface and because they're cooler they

91
00:03:46,550 --> 00:03:44,340
emit less thermal infrared radiation to

92
00:03:49,550 --> 00:03:46,560
space so they have a net warming effect

93
00:03:51,350 --> 00:03:49,560
on the climate clouds at low altitudes

94
00:03:53,869 --> 00:03:51,360
on the other hand are generally thicker

95
00:03:55,070 --> 00:03:53,879
and reflect more solar radiation back

96
00:03:58,009 --> 00:03:55,080
out to space

97
00:04:00,470 --> 00:03:58,019
they're also typically warmer so they

98
00:04:02,210 --> 00:04:00,480
emit more thermal infrared radiation and

99
00:04:03,410 --> 00:04:02,220
therefore have a net cooling effect on

100
00:04:08,449 --> 00:04:03,420
the climate

101
00:04:10,789 --> 00:04:08,459
Earth can respond in ways that leads to

102
00:04:13,190 --> 00:04:10,799
further warming for example as

103
00:04:14,990 --> 00:04:13,200
temperatures increase we see snowpack

104
00:04:17,810 --> 00:04:15,000
and sea ice melting away in polar

105
00:04:20,509 --> 00:04:17,820
regions a loss of white surfaces that

106
00:04:22,430 --> 00:04:20,519
reflect the solar radiation that means

107
00:04:25,430 --> 00:04:22,440
darker colored land and oceans Left

108
00:04:27,469 --> 00:04:25,440
Behind absorb more solar radiation and

109
00:04:28,310 --> 00:04:27,479
so more heat is added to the climate

110
00:04:31,790 --> 00:04:28,320
system

111
00:04:33,950 --> 00:04:31,800
this cycle of more heat more melt and

112
00:04:35,689 --> 00:04:33,960
more absorption of solar radiation is

113
00:04:37,670 --> 00:04:35,699

called a feedback cycle

114
00:04:40,189 --> 00:04:37,680
and it doesn't end there

115
00:04:43,310 --> 00:04:40,199
a feedback cycle also happens with

116
00:04:45,770 --> 00:04:43,320
clouds climate models predict a decrease

117
00:04:48,409 --> 00:04:45,780
in low altitude cloud coverage over the

118
00:04:50,990 --> 00:04:48,419
globe as the climate warms since low

119
00:04:53,150 --> 00:04:51,000
clouds are the highly reflective type a

120
00:04:54,890 --> 00:04:53,160
decrease in low cloud coverage means

121
00:04:57,770 --> 00:04:54,900
more heat will be added to the Earth's

122
00:04:59,870 --> 00:04:57,780
system leading to further warming

123
00:05:02,330 --> 00:04:59,880
and clouds impact the climate in another

124
00:05:05,030 --> 00:05:02,340
way too through the water cycle

125
00:05:07,370 --> 00:05:05,040
producing rain and snowfall

126
00:05:09,409 --> 00:05:07,380
water at Earth's surface evaporates

127
00:05:12,050 --> 00:05:09,419
providing the atmosphere with a supply

128
00:05:14,570 --> 00:05:12,060
of water vapor depending on the air

129
00:05:16,730 --> 00:05:14,580
temperature and atmospheric pressure the

130
00:05:19,730 --> 00:05:16,740
air Can Only Hold so much water vapor

131
00:05:22,490 --> 00:05:19,740
until it becomes saturated when that air

132
00:05:24,469 --> 00:05:22,500
is saturated with water vapor cools the

133
00:05:27,890 --> 00:05:24,479
water vapor turns back into liquid water

134
00:05:29,870 --> 00:05:27,900
droplets and forms clouds

135
00:05:32,110 --> 00:05:29,880
when these droplets or ice crystals

136
00:05:35,029 --> 00:05:32,120
accumulate that is what we call a cloud

137
00:05:37,249 --> 00:05:35,039
when the droplets or ice crystals within

138
00:05:38,990 --> 00:05:37,259

the cloud grow to be large enough they

139
00:05:42,529 --> 00:05:39,000
eventually fall to the ground or ocean

140
00:05:44,689 --> 00:05:42,539
as rain snow or hail

141
00:05:45,529 --> 00:05:44,699
this brings us back to the mystery at

142
00:05:48,230 --> 00:05:45,539
hand

143
00:05:50,749 --> 00:05:48,240
because clouds both reflect and absorb

144
00:05:53,270 --> 00:05:50,759
energy from the Sun impacting both ends

145
00:05:55,790 --> 00:05:53,280
of the radiation balance and play a

146
00:05:57,830 --> 00:05:55,800
massive role in the water cycle any

147
00:05:59,510 --> 00:05:57,840
changes in clouds will result in a

148
00:06:01,850 --> 00:05:59,520
change in our climate

149
00:06:04,490 --> 00:06:01,860
but clouds are also produced by our

150
00:06:07,010 --> 00:06:04,500
climate so any change in climate will

151
00:06:09,409 --> 00:06:07,020
result in a change in clouds

152
00:06:11,210 --> 00:06:09,419
as you probably now realize the

153
00:06:14,210 --> 00:06:11,220
relationship between clouds and the

154
00:06:16,610 --> 00:06:14,220
climate is incredibly complex and NASA

155
00:06:19,010 --> 00:06:16,620
is on a mission to understand it

156
00:06:21,230 --> 00:06:19,020
using NASA's earth-observing Fleet of

157
00:06:23,990 --> 00:06:21,240
satellites like Calypso and instruments

158
00:06:26,210 --> 00:06:24,000
like Ceres and Modis scientists have

159
00:06:27,950 --> 00:06:26,220
been collecting vital data on clouds to

160
00:06:31,070 --> 00:06:27,960
be able to precisely model their

161
00:06:33,230 --> 00:06:31,080
behavior a key ingredient to unraveling

162
00:06:35,050 --> 00:06:33,240
the mystery of clouds lies in the

163
00:06:37,430 --> 00:06:35,060

collection of global accurate

164
00:06:39,650 --> 00:06:37,440
multi-decado climate data records of

165
00:06:41,689 --> 00:06:39,660
cloud properties and their influence on

166
00:06:43,969 --> 00:06:41,699
Earth's radiation budget

167
00:06:45,590 --> 00:06:43,979
once we can accurately and fully

168
00:06:47,870 --> 00:06:45,600
understand the physics of clouds through

169
00:06:49,370 --> 00:06:47,880
observations that data can then be used

170
00:06:51,650 --> 00:06:49,380
to help improve climate and weather

171
00:06:52,010 --> 00:06:51,660
models so we can better prepare for the