1
00:00:02,440 --> 00:00:04,440
■

2
00:00:04,720 --> 00:00:08,360
>>Carl Sagan once defined the
Earth as the "Pale Blue Dot".

3
00:00:15,560 --> 00:00:18,440
70% of its surface
is covered by water.

4
00:00:23,680 --> 00:00:25,920
Life on our planet
began in the oceans

5
00:00:25,920 --> 00:00:28,200
some 3.5 billion years ago.

6
00:00:32,360 --> 00:00:35,640
Since then, water has been
an essential component for us.

7
00:00:36,000 --> 00:00:39,320
In fact, two thirds of our
bodies are made out of water.

8
00:00:42,480 --> 00:00:44,440
We can't imagine
life without it.

9
00:00:44,440 --> 00:00:47,600
As far as we know, without the
presence of liquid water,

10
00:00:47,600 --> 00:00:49,320
life is not possible...

11
00:00:49,320 --> 00:00:50,320
at all!

12
00:00:53,600 --> 00:00:55,480
Water is all around us.

13
00:00:56,640 --> 00:00:59,600
It's not only in our oceans.
But we also find it

14
00:00:59,600 --> 00:01:03,640
in rivers, lakes,
ice, rain, clouds...

15
00:01:04,120 --> 00:01:05,840
even in the air we breathe in,

16
00:01:05,840 --> 00:01:09,080
as it's continuously evaporating
into the atmosphere.

17
00:01:13,400 --> 00:01:17,040
■

18
00:01:36,080 --> 00:01:38,120
>>Water is important for all life.

19
00:01:38,480 --> 00:01:41,680
We wouldn't have life on this
planet if there wasn't water.

20
00:01:42,120 --> 00:01:44,600
When astronomers try to think
about other planets

21
00:01:44,600 --> 00:01:45,960
and whether they
have life on it,

22
00:01:45,960 --> 00:01:46,880
the first question they ask is:

23
00:01:46,880 --> 00:01:48,560
"Is there liquid water?"

24
00:01:49,040 --> 00:01:53,360
>>We have liquid water covering
nearly the entire planet.

25
00:01:53,360 --> 00:01:55,400
70% of the planet is
covered by water.

26
00:01:55,640 --> 00:01:58,840
There's water in our atmosphere,
in the air all around us.

27
00:01:59,080 --> 00:02:02,280
You don't find any place, any
chunk of air in the atmosphere

28
00:02:02,280 --> 00:02:04,840
that doesn't have some
water molecules,

29
00:02:04,840 --> 00:02:08,600
or some ice particles, or
some water droplets in it.

30
00:02:08,960 --> 00:02:12,200
>>Without water as part
of the climate system

31
00:02:12,200 --> 00:02:15,560
we would have wild temperature
swings in our atmosphere

32
00:02:15,560 --> 00:02:19,200
that would probably make
any planet uninhabitable.

33
00:02:19,600 --> 00:02:21,480
So, water is a key driver.

34
00:02:29,000 --> 00:02:30,640
>>Water is everywhere.

35
00:02:30,920 --> 00:02:34,960
Now, the way water begins,
is a liquid out here

36
00:02:34,960 --> 00:02:39,560
and the sun beats down on the
surface, and it warms the water.

37
00:02:39,560 --> 00:02:40,720
It evaporates it.

38
00:02:40,720 --> 00:02:43,640
Just like on your stove,
you put your pot of water

39
00:02:43,640 --> 00:02:45,920
and your heating
element below it,

40
00:02:45,920 --> 00:02:47,680
heats it up
and it boils off.

41
00:02:47,680 --> 00:02:49,920
You get steam or
you get water vapor.

42
00:02:49,920 --> 00:02:54,760
Same way that the sun's energy
will warm and evaporate water.

43
00:02:59,680 --> 00:03:02,600
That water rises in our

atmosphere and, as it rises,

44
00:03:02,600 --> 00:03:06,040
temperatures are cooler aloft
and so you form clouds.

45
00:03:06,040 --> 00:03:08,840
Clouds are water particles.

46
00:03:09,040 --> 00:03:10,680
>>They are little liquid
water particles,

47
00:03:10,680 --> 00:03:13,800
some are very tiny,
and they float around as clouds.

48
00:03:13,800 --> 00:03:16,480
They can also freeze
and form ice particles

49
00:03:16,480 --> 00:03:19,120
and those ice particles float
around, those are also clouds.

50
00:03:28,000 --> 00:03:31,400
As the atmosphere moves
that water vapor around

51
00:03:31,400 --> 00:03:35,560
and those cloud droplets,
they fall out of the sky,

52
00:03:35,560 --> 00:03:39,400
and they come down to the
surface and they feed our lakes,

53
00:03:39,400 --> 00:03:43,560
and our streams, and make the
soil wet so that crops can grow.

54
00:03:43,920 --> 00:03:47,680
Water is really a fundamental
part of our planet.

55
00:03:47,680 --> 00:03:50,160
It goes back to the oceans,

56
00:03:50,160 --> 00:03:51,920
and then it goes through
this cycle again.

57
00:03:51,920 --> 00:03:55,520
You get this constant
heating up of liquid water,

58
00:03:55,520 --> 00:03:58,920
becomes a gas, it precipitates
out onto the land,

59
00:03:58,920 --> 00:04:02,800
and it drives this what we
call the hydrological cycle.

60
00:04:17,080 --> 00:04:19,560
>>So as water comes
into the atmosphere,

61
00:04:19,560 --> 00:04:21,520
it has a number of effects.

62
00:04:21,520 --> 00:04:24,960
It helps to make clouds,
it helps to make rain.

63
00:04:24,960 --> 00:04:28,360
But water is actually a very
important greenhouse gas.

64

00:04:28,720 --> 00:04:31,320
>>Also, water carries
energy with it.

65
00:04:31,640 --> 00:04:35,680
It takes a lot of energy
to evaporate water,

66
00:04:35,680 --> 00:04:39,480
and then when water forms cloud
droplets, it releases energy.

67
00:04:40,200 --> 00:04:44,600
So water is a big component of
not only the hydrological cycle,

68
00:04:44,600 --> 00:04:45,960
the movement of water,

69
00:04:45,960 --> 00:04:48,480
but the energy cycle
of the planet also.

70
00:04:48,480 --> 00:04:50,120
Because it's a greenhouse gas

71
00:04:50,120 --> 00:04:53,720
and because when you evaporate
water it carries a lot of energy

72
00:04:54,080 --> 00:04:55,560
>>So, the way it works is,

73
00:04:55,560 --> 00:04:59,160
when we change the atmosphere,
put more carbon dioxide in it,

74
00:04:59,160 --> 00:05:00,360
it gets warmer

75
00:05:00,360 --> 00:05:02,920
and that allows the atmosphere
to hold more water.

76
00:05:03,200 --> 00:05:05,240
But water is also
a greenhouse gas,

77
00:05:05,240 --> 00:05:07,400
so that increases the
temperature further.

78
00:05:07,400 --> 00:05:08,960
So it's a feedback effect.

79
00:05:09,440 --> 00:05:13,200
>>Water being a strong greenhouse
gas, will actually amplify

80
00:05:13,200 --> 00:05:16,640
the greenhouse gas effect from
these other longer lived species

81
00:05:16,640 --> 00:05:18,720
like carbon dioxide
and methane.

82
00:05:18,720 --> 00:05:21,800
So that is a very strong
positive feedback loop

83
00:05:21,800 --> 00:05:23,480
which would keep driving
the temperature up.

84
00:05:23,840 --> 00:05:25,840
>>Or, you can create more clouds

85
00:05:25,840 --> 00:05:28,600

and reflect more
energy back to space

86
00:05:28,880 --> 00:05:31,000
which is what we call
a negative feedback.

87
00:05:31,400 --> 00:05:33,440
>>So we have this complicated
interaction between

88
00:05:33,440 --> 00:05:36,920
the positive feedbacks from
the water vapor itself,

89
00:05:36,920 --> 00:05:40,480
versus the clouds that it forms
giving you a negative feedback.

90
00:05:40,840 --> 00:05:42,320
And finding that right balance...

91
00:05:42,320 --> 00:05:44,240
that's part of what we're
trying to understand

92
00:05:44,240 --> 00:05:46,080
with the entire
hydrological cycle

93
00:05:46,080 --> 00:05:48,000
in the tropical part
of the atmosphere.

94
00:05:48,400 --> 00:05:49,360
>>And it turns out,

95
00:05:49,360 --> 00:05:52,520
about half of the change in
temperature of the atmosphere

96
00:05:52,520 --> 00:05:55,320
right now and the change
predicted in the future,

97
00:05:55,320 --> 00:05:58,320
associated with increasing
carbon dioxide,

98
00:05:58,640 --> 00:06:01,040
is caused by this
water vapor feedback.

99
00:06:01,360 --> 00:06:02,760
>>Water comes and goes

100
00:06:02,760 --> 00:06:05,920
and that's driven purely by the
physics of how water works.

101
00:06:05,920 --> 00:06:07,960
It's a reactionary
greenhouse gas

102
00:06:07,960 --> 00:06:10,960
as opposed to a longer lived
stable greenhouse gas.

103
00:06:11,440 --> 00:06:13,720
But water is the big player

104
00:06:13,720 --> 00:06:17,080
in the entire feedback loops
of how the atmosphere works.

105
00:06:24,560 --> 00:06:28,320
>>It's very warm here
in the tropics

106

00:06:28,320 --> 00:06:30,440
and it's very moist...!

107
00:06:30,800 --> 00:06:34,640
So the air near the surface
has a lot of energy in it.

108
00:06:35,040 --> 00:06:39,960
>>So deep convection, in the form
of thunderstorms and typhoons,

109
00:06:39,960 --> 00:06:43,800
actually are more energetic,
they go to higher altitudes.

110
00:06:44,200 --> 00:06:45,800
>>And so, they can go quite high.

111
00:06:45,800 --> 00:06:48,320
We see these big
thunderstorms that develop

112
00:06:48,320 --> 00:06:50,520
and that's this air
being funneled up

113
00:06:50,520 --> 00:06:52,640
just like a boiling
pot of water.

114
00:06:52,880 --> 00:06:56,880
The air gets funneled up into
the upper troposphere here

115
00:06:56,880 --> 00:06:58,680
and actually go very high.

116
00:06:58,960 --> 00:07:03,520
>>So that extends the troposphere
upward to higher altitudes

117
00:07:03,520 --> 00:07:06,040
and the temperature keeps
decreasing as you go up

118
00:07:06,040 --> 00:07:07,520
and so it's colder.

119
00:07:07,800 --> 00:07:12,120
>>And so eventually, most of
the water, gets frozen out

120
00:07:12,120 --> 00:07:15,600
as you get up to these altitudes
of 50,000 or 60,000 feet.

121
00:07:15,920 --> 00:07:19,080
So it's incredibly dry. Even
though down at the surface

122
00:07:19,080 --> 00:07:22,320
in the tropics,
it's very wet and moist,

123
00:07:22,320 --> 00:07:24,360
it's very high humidity,
it's damp...

124
00:07:24,360 --> 00:07:28,880
When you get to 55,000 feet
(about 16 kilometers up)

125
00:07:28,880 --> 00:07:30,840
it's incredibly dry!

126
00:07:31,280 --> 00:07:32,920
>>But you still get some
water making it up

127

00:07:32,920 --> 00:07:34,680
to the tropical tropopause

128
00:07:34,680 --> 00:07:36,520
and there, the
atmospheric motions,

129
00:07:36,520 --> 00:07:38,560
transport air into
the stratosphere.

130
00:07:38,920 --> 00:07:40,880
So air is transported
into the stratosphere

131
00:07:40,880 --> 00:07:43,400
with a small amount of
water that's left behind

132
00:07:43,400 --> 00:07:45,640
and that's controlled
by the temperatures

133
00:07:45,640 --> 00:07:47,800
at the tropical tropopause.

134
00:07:48,840 --> 00:07:50,680
So if the tropopause is colder,

135
00:07:50,680 --> 00:07:52,840
less water will make it
into the stratosphere.

136
00:07:52,840 --> 00:07:54,400
If it's somewhat warmer,

137
00:07:54,400 --> 00:07:57,120
more water will make it
into the stratosphere.

138
00:07:59,600 --> 00:08:03,720
>>Above us, up at 40 - 50
thousand feet in the tropics

139
00:08:03,720 --> 00:08:07,480
the atmosphere is going to
warm up through this century.

140
00:08:07,960 --> 00:08:09,120
And because of that,

141
00:08:09,120 --> 00:08:14,880
there will be less freeze-drying
of this air going up.

142
00:08:15,280 --> 00:08:19,600
And so the thinking is
that water might go up.

143
00:08:20,160 --> 00:08:22,280
Now, water is a powerful
greenhouse gas.

144
00:08:22,280 --> 00:08:25,320
So if water increases,
at those higher altitudes,

145
00:08:25,320 --> 00:08:28,920
it will act to trap more
energy at the surface.

146
00:08:29,400 --> 00:08:34,840
It could cause the temperature
to actually go up higher.

147
00:08:35,160 --> 00:08:39,000
>>Climate change will have huge
impacts on food supply...

148

00:08:39,000 --> 00:08:45,320
on ocean levels and
flooding of coastal regions.

149
00:08:45,640 --> 00:08:47,000
>>It's important to understand...

150
00:08:47,000 --> 00:08:49,480
Put all of this together
to understand

151
00:08:49,480 --> 00:08:52,680
how water will change
through the next century.

152
00:08:53,000 --> 00:08:55,160
>>The more we understand
the processes,

153
00:08:55,160 --> 00:08:58,560
the better off society
will be because of it.

154
00:09:05,520 --> 00:09:08,200
>>ATTREX, and studying
the tropical tropopause,

155
00:09:08,200 --> 00:09:11,800
is addressing a key uncertainty
in our ability to predict

156
00:09:11,800 --> 00:09:17,720
future changes in climate in
response to human influences.

157
00:09:18,840 --> 00:09:22,600
■

158
00:09:30,000 --> 00:09:32,320
>>It is believed that Guam

was first discovered

159
00:09:32,320 --> 00:09:35,400
by seafaring people who
migrated from southeast Asia

160
00:09:35,400 --> 00:09:37,160
around 2,000 BC.

161
00:09:58,840 --> 00:10:01,360
When Portuguese explorer
Ferdinand Magellan,

162
00:10:01,360 --> 00:10:03,920
arrived at the island
in the 16th century,

163
00:10:04,280 --> 00:10:06,720
he found a highly
stratified society.

164
00:10:07,080 --> 00:10:10,480
Experts in the art of sailing
and skilled craftspeople.

165
00:10:10,640 --> 00:10:12,080
the Chamorro.

166
00:10:16,640 --> 00:10:18,640
Since then, numerous expeditions

167
00:10:18,640 --> 00:10:20,880
have investigated this
region of the Pacific.

168
00:10:21,200 --> 00:10:23,800
Yet, there are still many
discoveries to be made

169

00:10:23,800 --> 00:10:25,840
and places to be explored.

170
00:10:26,600 --> 00:10:28,680
Although this time,
we'll be looking up,