
00 01 02 03 04 05 06 07 08 09 10 11

1
00:00:06,389 --> 00:00:04,070
from a spy glass to satellites our

2
00:00:09,430 --> 00:00:06,399
backyard to the very edge of our solar

3
00:00:11,350 --> 00:00:09,440
system every culture on every continent

4
00:00:12,870 --> 00:00:11,360
has observed the sun

5
00:00:15,190 --> 00:00:12,880
we have been searching for the answers

6
00:00:17,269 --> 00:00:15,200
to the mysteries of time and the seasons

7
00:00:19,429 --> 00:00:17,279
the web of life on earth

8
00:00:21,750 --> 00:00:19,439
and our place in the universe

9
00:00:23,750 --> 00:00:21,760
our sun has always been more than a ball

10
00:00:25,750 --> 00:00:23,760
of heat and light

11
00:00:28,390 --> 00:00:25,760
our sun through curious minds and

12
00:00:30,630 --> 00:00:28,400
innovative technology has allowed us to

13
00:00:33,510 --> 00:00:30,640

explore how the northern lights dance

14
00:00:50,790 --> 00:00:33,520
and how our solar system may have formed

15
00:00:55,270 --> 00:00:52,869
before sophisticated satellites brought

16
00:00:58,069 --> 00:00:55,280
us vibrant images and wavelengths beyond

17
00:00:59,110 --> 00:00:58,079
our senses people simply looked at the

18
00:01:01,430 --> 00:00:59,120
sun

19
00:01:05,030 --> 00:01:01,440
although he was not alone in his pursuit

20
00:01:07,590 --> 00:01:05,040
in 1609 galileo galilei pioneered the

21
00:01:10,950 --> 00:01:07,600
use of the telescope in order to observe

22
00:01:16,789 --> 00:01:13,350
his detailed sketches produced over the

23
00:01:19,190 --> 00:01:16,799
summer in 1612 revealed that the sun was

24
00:01:23,510 --> 00:01:19,200
not a static orb in the sky but a

25
00:01:28,310 --> 00:01:26,070
galileo's solar discoveries sparked an

26
00:01:29,990 --> 00:01:28,320
academic interest in the sun leading

27
00:01:32,390 --> 00:01:30,000
astronomers around the world to

28
00:01:33,670 --> 00:01:32,400
investigate how the sun shapes life on

29
00:01:35,990 --> 00:01:33,680
earth

30
00:01:38,710 --> 00:01:36,000
400 years later astronomers with

31
00:01:40,870 --> 00:01:38,720
increasingly complex satellite imagers

32
00:01:48,630 --> 00:01:40,880
investigate the origins and effects of

33
00:01:52,870 --> 00:01:50,789
there must be something in a sunspot

34
00:01:54,710 --> 00:01:52,880
that opens up a wealth of knowledge and

35
00:01:56,789 --> 00:01:54,720
even more questions

36
00:01:59,190 --> 00:01:56,799
like galileo before him german

37
00:02:01,670 --> 00:01:59,200
astronomer samuel heinrich schwab became

38
00:02:04,709 --> 00:02:01,680

fascinated with sunspots from careful

39
00:02:07,030 --> 00:02:04,719
observation over 17 years schwab found a

40
00:02:08,389 --> 00:02:07,040
periodic cycling of the average number

41
00:02:10,469 --> 00:02:08,399
of sunspots

42
00:02:12,470 --> 00:02:10,479
in the mid-1800s he and other

43
00:02:15,030 --> 00:02:12,480
astronomers found that the sun has about

44
00:02:16,949 --> 00:02:15,040
an 11-year cycle between the times when

45
00:02:18,390 --> 00:02:16,959
we can observe the most and the least

46
00:02:20,550 --> 00:02:18,400
sunspots

47
00:02:22,550 --> 00:02:20,560
understanding the 11-year solar cycle

48
00:02:24,229 --> 00:02:22,560
becomes very crucial in understanding

49
00:02:26,630 --> 00:02:24,239
the effects of space weather here at

50
00:02:29,030 --> 00:02:26,640
earth because it really dictates how

51
00:02:40,949 --> 00:02:29,040
often solar storms will occur and how

52
00:02:45,589 --> 00:02:43,270
we often underestimate how beautiful a

53
00:02:47,430 --> 00:02:45,599
scientific discovery can be

54
00:02:50,070 --> 00:02:47,440
when the themis satellite fleet launched

55
00:02:53,110 --> 00:02:50,080
in 2007 the mission set out to

56
00:02:55,430 --> 00:02:53,120
investigate what triggers substorms

57
00:02:57,589 --> 00:02:55,440
substorms are atmospheric events visible

58
00:02:59,830 --> 00:02:57,599
in the northern hemisphere as a sudden

59
00:03:03,589 --> 00:02:59,840
brightening of the northern lights or

60
00:03:09,430 --> 00:03:06,949
one such substorm in march 2008 produced

61
00:03:12,949 --> 00:03:09,440
lightning fast aurora with the energy of

62
00:03:17,110 --> 00:03:14,949
nasa scientists found the answer to this

63
00:03:20,229 --> 00:03:17,120

mysterious behavior and massive energy

64
00:03:22,869 --> 00:03:20,239
in giant magnetic ropes

65
00:03:24,550 --> 00:03:22,879
these can be as wide as the earth itself

66
00:03:26,390 --> 00:03:24,560
serve as conduits for solar wind

67
00:03:28,710 --> 00:03:26,400
particles which collide with the earth's

68
00:03:31,910 --> 00:03:28,720
magnetic field and charge the

69
00:03:33,589 --> 00:03:31,920
spectacular substorms and auroras these

70
00:03:35,270 --> 00:03:33,599
ropes are evidence of a direct

71
00:03:37,430 --> 00:03:35,280
connection between the sun and the

72
00:03:39,910 --> 00:03:37,440
earth's upper atmosphere

73
00:03:41,990 --> 00:03:39,920
it is when these ropes form and unravel

74
00:03:44,229 --> 00:03:42,000
that the highly energetic solar wind

75
00:03:46,470 --> 00:03:44,239
ignites the earth's magnetic field and

76
00:03:48,789 --> 00:03:46,480
lights up the northern sky providing a

77
00:04:02,229 --> 00:03:48,799
celestial dance that has captivated

78
00:04:06,390 --> 00:04:04,470
sometimes a great discovery is a new

79
00:04:09,509 --> 00:04:06,400
perspective on the universe we thought

80
00:04:13,589 --> 00:04:11,350
as the voyager spacecraft's near the

81
00:04:16,310 --> 00:04:13,599
edge of our sun's reach scientists are

82
00:04:19,590 --> 00:04:16,320
getting a new look at the expanse and

83
00:04:22,469 --> 00:04:19,600
shape of the solar system

84
00:04:27,430 --> 00:04:22,479
over 30 years ago voyager 1 and 2 set

85
00:04:31,670 --> 00:04:29,510
now as the twin spacecrafts explore the

86
00:04:33,749 --> 00:04:31,680
outer reaches some nine billion miles

87
00:04:36,310 --> 00:04:33,759
away from earth they have crossed the

88
00:04:39,909 --> 00:04:36,320

heliosphere the bubble of supersonic

89
00:04:43,749 --> 00:04:41,909
however when voyager 2 crossed this

90
00:04:46,150 --> 00:04:43,759
boundary much closer to the sun than

91
00:04:48,870 --> 00:04:46,160
expected we received a picture of a

92
00:04:50,070 --> 00:04:48,880
squashed heliosphere rather than a round

93
00:04:51,590 --> 00:04:50,080
bubble

94
00:04:53,670 --> 00:04:51,600
the squashed heliosphere helps

95
00:04:56,150 --> 00:04:53,680
scientists build up a picture of how the

96
00:04:58,150 --> 00:04:56,160
sun interacts with the space outside of

97
00:05:00,310 --> 00:04:58,160
our solar system

98
00:05:02,469 --> 00:05:00,320
when the recently launched ibex or

99
00:05:04,870 --> 00:05:02,479
interstellar boundary explorer reaches

100
00:05:06,390 --> 00:05:04,880
the very distant limits it will further

101
00:05:08,710 --> 00:05:06,400
the study of how the solar wind

102
00:05:17,430 --> 00:05:08,720
interacts with the cold gas between

103
00:05:21,670 --> 00:05:19,510
it's hard to imagine weather being more

104
00:05:22,790 --> 00:05:21,680
than rain on our weekend or ice on our

105
00:05:25,510 --> 00:05:22,800
roads

106
00:05:27,749 --> 00:05:25,520
but space weather can affect the globe

107
00:05:29,510 --> 00:05:27,759
especially in the way we communicate and

108
00:05:31,270 --> 00:05:29,520
power our world

109
00:05:33,590 --> 00:05:31,280
space weather is the environmental

110
00:05:35,670 --> 00:05:33,600
conditions outside of our planet

111
00:05:38,230 --> 00:05:35,680
originating from the massively energetic

112
00:05:40,469 --> 00:05:38,240
output of the sun the solar wind is

113
00:05:42,390 --> 00:05:40,479

primarily comprised of protons and

114
00:05:44,469 --> 00:05:42,400
electrons they're streaming outward from

115
00:05:47,029 --> 00:05:44,479
the sun at speeds of up to a million

116
00:05:50,710 --> 00:05:47,039
miles an hour and they're constantly

117
00:05:52,390 --> 00:05:50,720
bombarding the earth's magnetic field

118
00:05:55,029 --> 00:05:52,400
satellites have been launched to study

119
00:06:01,510 --> 00:05:55,039
solar wind solar flares coronal mass

120
00:06:07,510 --> 00:06:03,909
these phenomena impact our atmosphere

121
00:06:10,230 --> 00:06:07,520
sometimes with devastating force

122
00:06:13,029 --> 00:06:10,240
so space weather includes power outages

123
00:06:15,430 --> 00:06:13,039
in high latitude power grids includes

124
00:06:17,590 --> 00:06:15,440
disruption of spacecraft includes

125
00:06:18,469 --> 00:06:17,600
radiation that can harm astronauts in

126
00:06:21,990 --> 00:06:18,479
space

127
00:06:23,990 --> 00:06:22,000
with any weather prediction is the goal

128
00:06:26,150 --> 00:06:24,000
these missions will all add to the