



1  
00:00:08,070 --> 00:00:05,749  
the atlas instrument on the icesat-2

2  
00:00:10,310 --> 00:00:08,080  
satellite measures elevation by timing

3  
00:00:12,310 --> 00:00:10,320  
the flight of laser light pulses that

4  
00:00:15,270 --> 00:00:12,320  
leave the satellite bounce off the

5  
00:00:17,590 --> 00:00:15,280  
surface and return to atlas

6  
00:00:20,070 --> 00:00:17,600  
the speed of light is very fast and so a

7  
00:00:22,870 --> 00:00:20,080  
regular stopwatch would give us too wide

8  
00:00:25,269 --> 00:00:22,880  
a range of time a big margin of error

9  
00:00:27,429 --> 00:00:25,279  
the timing has to be ultra precise less

10  
00:00:29,029 --> 00:00:27,439  
than one billionth of a second in order

11  
00:00:31,509 --> 00:00:29,039  
to measure the height of the surface

12  
00:00:33,510 --> 00:00:31,519  
within just a few centimeters

13  
00:00:35,830 --> 00:00:33,520

i'm phil lars i'm deputy instrument

14

00:00:38,150 --> 00:00:35,840

system engineer on the atlas instrument

15

00:00:39,990 --> 00:00:38,160

on the icesat-2 mission

16

00:00:41,830 --> 00:00:40,000

calculating the elevation of the ice is

17

00:00:44,069 --> 00:00:41,840

all about time of flight it's

18

00:00:47,190 --> 00:00:44,079

time-of-flight of the photon from the

19

00:00:50,709 --> 00:00:47,200

laser down to the surface of the ice and

20

00:00:53,270 --> 00:00:50,719

back so what we are doing is creating

21

00:00:55,510 --> 00:00:53,280

time tags of the transmit when the laser

22

00:00:56,790 --> 00:00:55,520

fires and time tags of the receipt of

23

00:00:58,790 --> 00:00:56,800

the photon

24

00:01:00,790 --> 00:00:58,800

so it all starts with the transmitter

25

00:01:02,630 --> 00:01:00,800

when the laser fires it puts out

26  
00:01:04,229 --> 00:01:02,640  
billions and billions of photons we pick

27  
00:01:05,910 --> 00:01:04,239  
off a little bit of that and we send it

28  
00:01:07,270 --> 00:01:05,920  
to a detector and we produce a start

29  
00:01:09,910 --> 00:01:07,280  
pulse and that is the start of our

30  
00:01:12,230 --> 00:01:09,920  
timing system the spacecraft sends us a

31  
00:01:14,070 --> 00:01:12,240  
position and attitude message every

32  
00:01:16,870 --> 00:01:14,080  
second that tells us where we are in the

33  
00:01:19,030 --> 00:01:16,880  
orbit from that we calculate where we

34  
00:01:21,510 --> 00:01:19,040  
think the spots are on the ground we

35  
00:01:23,429 --> 00:01:21,520  
have a rough database of the whole earth

36  
00:01:25,190 --> 00:01:23,439  
with elevation as it travels up and down

37  
00:01:27,590 --> 00:01:25,200  
mountains and down into valleys and over

38  
00:01:29,510 --> 00:01:27,600

ice sheets for each spot we calculate

39

00:01:32,069 --> 00:01:29,520

where we think the surface is and we

40

00:01:34,630 --> 00:01:32,079

open up a range window for every photon

41

00:01:38,069 --> 00:01:34,640

that's received in that range window we

42

00:01:43,109 --> 00:01:40,630

now the sun produces a lot of green

43

00:01:45,590 --> 00:01:43,119

photons too many more than our laser

44

00:01:48,149 --> 00:01:45,600

does so our laser produces billions and

45

00:01:49,590 --> 00:01:48,159

billions of photons with every shot

46

00:01:52,310 --> 00:01:49,600

if you add the noise in there you won't

47

00:01:54,310 --> 00:01:52,320

be able to tell the sun's photons from

48

00:01:57,109 --> 00:01:54,320

the laser photons so if you just took

49

00:01:59,270 --> 00:01:57,119

one shot the one laser photon would be

50

00:02:00,950 --> 00:01:59,280

lost in the noise but if you take 200

51  
00:02:02,870 --> 00:02:00,960  
shots now finally you have enough

52  
00:02:05,270 --> 00:02:02,880  
surface signal coming out by the noise

53  
00:02:07,830 --> 00:02:05,280  
that fly software on board can pick out

54  
00:02:09,430 --> 00:02:07,840  
this is noise and this is the signal

55  
00:02:11,910 --> 00:02:09,440  
from the surface

56  
00:02:13,830 --> 00:02:11,920  
once we downlink the photon time tags

57  
00:02:15,510 --> 00:02:13,840  
from the receiver and the transmitter

58  
00:02:17,589 --> 00:02:15,520  
and we have the range windows you put

59  
00:02:19,589 --> 00:02:17,599  
those all together you have the transmit

60  
00:02:21,670 --> 00:02:19,599  
time tags you have the time until the

61  
00:02:24,070 --> 00:02:21,680  
range window opened you have the receive

62  
00:02:25,110 --> 00:02:24,080  
time tags in the range window you

63  
00:02:27,030 --> 00:02:25,120

calculate

64

00:02:29,350 --> 00:02:27,040

all that put together gives you the time

65

00:02:30,790 --> 00:02:29,360

of flight of a photon which ultimately

66

00:02:32,869 --> 00:02:30,800

gives you the distance between the

67

00:02:34,630 --> 00:02:32,879

spacecraft and the ground so if you know

68

00:02:36,150 --> 00:02:34,640

where the spacecraft is and you know the

69

00:02:37,990 --> 00:02:36,160

time of flight you know the distance to

70

00:02:38,920 --> 00:02:38,000

the ground now you have the elevation of

71

00:02:41,509 --> 00:02:38,930

the ice

72

00:02:43,350 --> 00:02:41,519

[Music]

73

00:02:45,509 --> 00:02:43,360

technology that can measure elevation

74

00:02:48,390 --> 00:02:45,519

adds a third dimension to how we map our

75

00:02:55,160 --> 00:02:48,400

earth and allows us to study change

