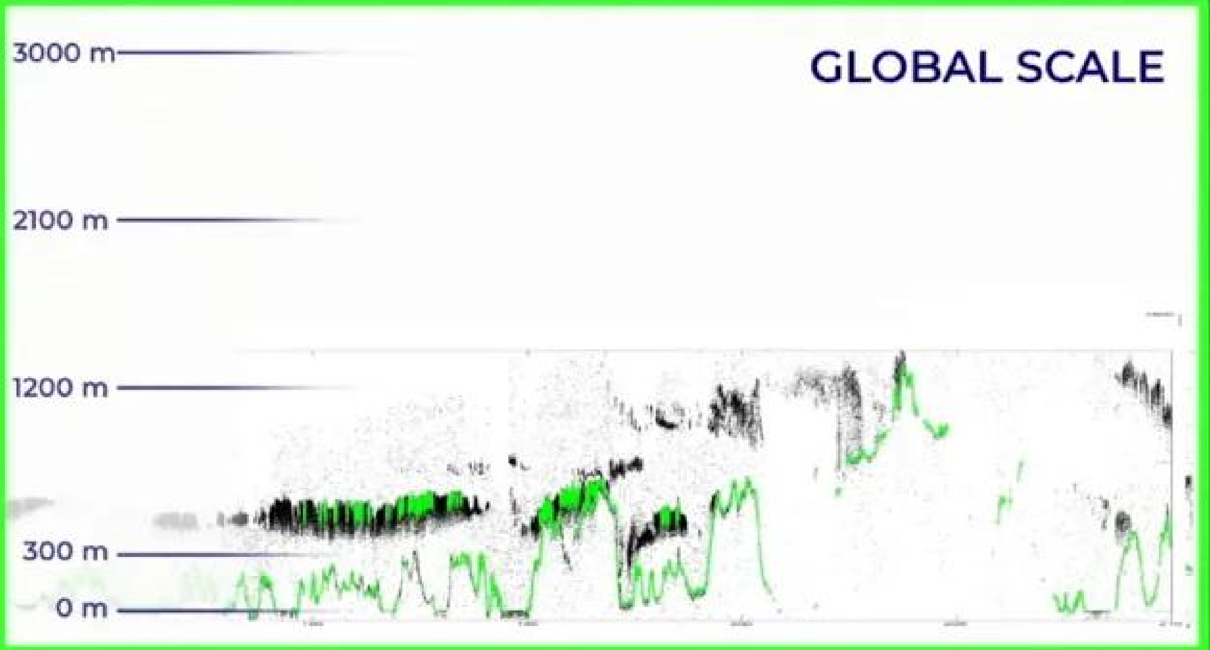
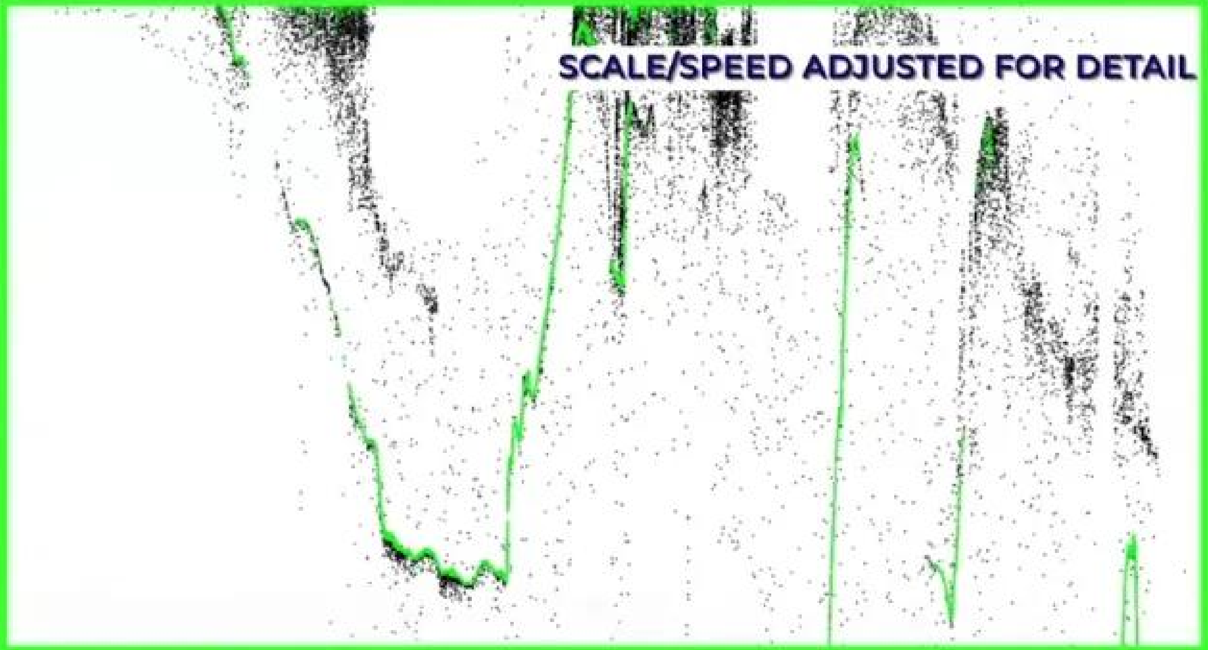
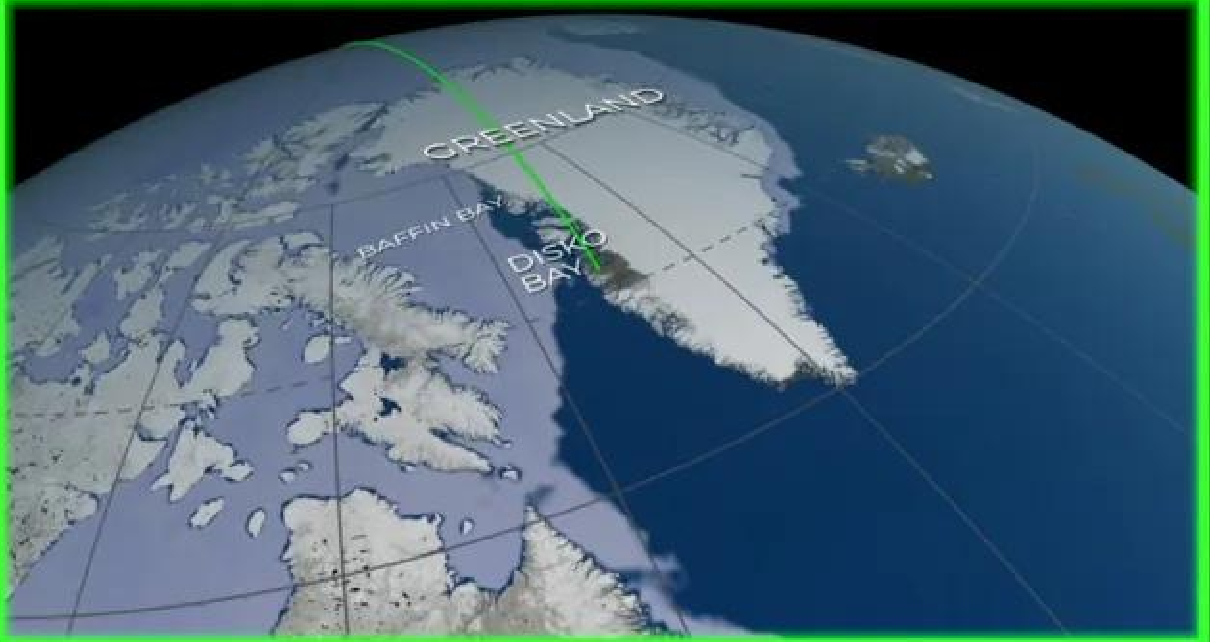

GLOBAL SCALE
3000 m
2100 m
1200 m
300 m
0 m


SCALE/SPEED ADJUSTED FOR DETAIL


GREENLAND
BAFFIN BAY
DISKO BAY

1
00:00:10,080 --> 00:00:14,400
Hi, I'm Tom Neumann, I'm the project\h scientist on the ICESat-2 mission.

2
00:00:14,400 --> 00:00:20,240
NASA's Ice, Cloud and land Elevation Satellite-2,\h or ICESat-2 as we call it, recently celebrated

3
00:00:20,240 --> 00:00:26,800
its second year on orbit after launching from\h Vandenberg Air Force Base on September 15, 2018.

4
00:00:26,800 --> 00:00:32,400
Hi, I'm Kaitlin Harbeck and I'm the data product\h manager for NASA's Ice, Cloud and land Elevation

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00:00:32,400 --> 00:00:38,400
Satellite-2, or ICESat-2 for short. For this\h Photon Phriday example, we actually took data

6
00:00:38,400 --> 00:00:43,600
from the same orbit collected on two different\h dates to capture the clearest, least cloudy data

7
00:00:43,600 --> 00:00:48,080
examples. Neumann: ICESat-2's main objective\h is to measure the elevation of the Earth, and

8
00:00:48,080 --> 00:00:53,200
as the name suggests, it's optimized to measure\h changes in icy areas. The way it does that is to

9
00:00:53,200 --> 00:00:59,520
transmit a very small pulse of laser light--green\h laser light in our case--and precisely time how

10
00:00:59,520 --> 00:01:04,720
long that light takes to go from the spacecraft\h to the ground and back up again. By combining

11
00:01:04,720 --> 00:01:09,920
that round-trip travel time information with\h information on where the satellite is in orbit

12
00:01:09,920 --> 00:01:14,400
and what direction it's pointing, through ground\h processing, we can determine what the elevation

13
00:01:14,400 --> 00:01:19,760

of the Earth is beneath the satellite. This is an\h example of the data we collect, known as ATL03,

14
00:01:19,760 --> 00:01:25,360
the global geolocated photon product. Hi I'm\h Nathan Kurtz, the deputy project scientist for

15
00:01:25,360 --> 00:01:29,920
ICESat-2. Now we're into the Arctic, this is\h where I'm familiar with, especially Arctic sea

16
00:01:29,920 --> 00:01:34,400
ice. You can see it kind of looks like an ocean\h return, but there's not quite as much structure.

17
00:01:34,400 --> 00:01:41,200
The surface isn't as rough as, say, an ocean that\h has a lot of swell and waves. So that return isn't

18
00:01:41,200 --> 00:01:47,440
as thick. The little structure that you do see is\h really from the ridges and things that are in the

19
00:01:47,440 --> 00:01:53,840
ice. So the ice kind of gets crushed together\h in places, and so that causes those returns.

20
00:01:53,840 --> 00:01:57,920
So now we're over Greenland and you can see\h Greenland's really high. You can see this really

21
00:01:57,920 --> 00:02:03,920
like dome-like structure, and that's interesting\h because it's how the ice sheet forms. Like it gets

22
00:02:03,920 --> 00:02:09,360
really high up near the center and gravity is\h just pushing this down all the time, and so the

23
00:02:09,360 --> 00:02:15,120
ice is slowly flowing out to the ocean. So you get\h this dome-like structure, but obviously here we're

24
00:02:15,120 --> 00:02:20,800
seeing more topography, things like mountains and\h stuff that the ice flows around. Neumann: For each

25
00:02:20,800 --> 00:02:26,960
of the photons detected by ICESat-2 on orbit,\h in ground processing, we determine the latitude,

26
00:02:26,960 --> 00:02:32,080
the longitude and the elevation of each one of\h those photons. Harbeck: These large collections

27
00:02:32,080 --> 00:02:37,440
of photons make up what we call the photon cloud.\h The photon clouds you're seeing on the screen now

28
00:02:37,440 --> 00:02:44,080
are examples of this ATL03 data product collected\h along reference ground track number 1352.

29
00:02:44,080 --> 00:02:47,680
These photon heights have been corrected\h for various geophysical phenomena,

30
00:02:47,680 --> 00:02:52,720
such as atmospheric effects and tides. Neumann:\h The photons colored in green indicate photons

31
00:02:52,720 --> 00:02:58,000
that ground processing has identified as most\h likely reflecting off the surface of the Earth.

32
00:02:58,000 --> 00:03:02,640
Over the oceans, we can see that the surface\h is very flat, much like we would expect.

33
00:03:02,640 --> 00:03:07,520
If we zoomed in on some of these areas we can\h see that the ATLAS instrument aboard ICESat-2

34
00:03:07,520 --> 00:03:12,800
is actually able to detect individual waves and\h ocean swells that are just slightly higher or

35
00:03:12,800 --> 00:03:18,320
slightly lower than the surrounding area. We also\h notice that the width of the photon cloud changes

36
00:03:18,320 --> 00:03:23,840
around the orbit. Over oceans where the surface\h is relatively flat, that photon window is fairly

37
00:03:23,840 --> 00:03:28,960
narrow because we have a very good idea ahead of\h time of where the ocean surface should be. As we

38
00:03:28,960 --> 00:03:34,400

transition onto land the width of that photon\h cloud gets much larger because there's a lot of

39
00:03:34,400 --> 00:03:39,520
roughness and topography over the terrestrial\h parts of Earth or over the ice sheets. And so

40
00:03:39,520 --> 00:03:45,510
ICESat-2 sends down a much wider band of photons\h over these areas in order to capture that surface.

41
00:03:47,440 --> 00:03:51,840
We notice that in some areas there's relatively\h few photons, and at other points around the orbit,

42
00:03:51,840 --> 00:03:57,680
the plot is almost solid with photons, and\h that's mainly due to the effects of the Sun.

43
00:03:57,680 --> 00:04:02,960
ATLAS uses green laser light, and it turns out\h that the Sun also emits a lot of light in the

44
00:04:02,960 --> 00:04:07,280
green part of the spectrum. So when ICESat-2\h is collecting data over sunlit surfaces,

45
00:04:07,280 --> 00:04:12,560
we see a lot of background photons in addition\h to the photons reflected off the Earth.

46
00:04:12,560 --> 00:04:16,640
In contrast, over dark surfaces at night,\h we see relatively few background photons,

47
00:04:16,640 --> 00:04:22,630
and we get a really clear surface return. Kurtz:\h That sharp diagonal feature in the photon return

48
00:04:30,160 --> 00:04:34,720
is from something called the transmitter echo\h path, or TEP. It comes from routing of some of

49
00:04:34,720 --> 00:04:39,760
the transmit laser power through to the detectors\h directly. Because we have two different TEP paths

50
00:04:39,760 --> 00:04:44,720
to know exactly how long the path delay should\h take, we're able to use deviations in the TEP

51
00:04:44,720 --> 00:04:50,960
to calibrate the instrument to account for\h things like thermal variations.

52
00:04:50,960 --> 00:04:56,240
Harbeck: At times ATLAS' onboard signal finding that is\h used as a first filter to approximate where the

53
00:04:56,240 --> 00:05:00,800
ground surface is located is unable to find\h the surface returns, owing to the reflection

54
00:05:00,800 --> 00:05:06,800
of sunlight from clouds. In those cases, the\h telemetry band may or may not include the surface.

55
00:05:06,800 --> 00:05:11,840
The telemetry band can change every 200\h shots, or roughly 140 meters along the

56
00:05:11,840 --> 00:05:16,240
satellite's track, which takes roughly 5\h one hundredths of a second to complete.

57
00:05:16,240 --> 00:05:20,560
The discontinuous bands of telemetered data and\h blocky features that you may be seeing on your

58
00:05:20,560 --> 00:05:26,550
screen are due to ATLAS detecting clouds\h and not necessarily the ground surface.

59
00:05:34,080 --> 00:05:38,880
Neumann: As we transition across the center of Antarctica,\h one area of interest for me anyway is a place

60
00:05:38,880 --> 00:05:43,920
called Hercules Dome. The National Science\h Foundation has funded a number of deep ice

61
00:05:43,920 --> 00:05:49,520
coring efforts in Antarctica over the past several\h decades that are all aimed to drill down through

62
00:05:49,520 --> 00:05:55,600
the ice sheet and collect ice from far back in\h time. The ice closest to the surface of the ice

63
00:05:55,600 --> 00:06:00,080

sheet is the youngest, having fallen as snow\h relatively recently. And as we drill deeper

64
00:06:00,080 --> 00:06:06,640
and deeper into the ice sheet, we collect ice\h that fell as snow many thousands of years ago.

65
00:06:06,640 --> 00:06:10,960
Hercules Dome is an interesting place to drill\h an ice core because it sits near the mountains,

66
00:06:10,960 --> 00:06:15,440
right at the edge between the East Antarctic\h ice sheet and the West Antarctic ice sheet.

67
00:06:15,440 --> 00:06:19,040
Models and observations suggest that the\h West Antarctic ice sheet is a much more

68
00:06:19,040 --> 00:06:25,120
dynamic ice sheet than the much larger and most\h likely much older East Antarctic ice sheet.

69
00:06:25,120 --> 00:06:28,800
And by drilling right at Hercules Dome,\h scientists hope to be able to understand

70
00:06:28,800 --> 00:06:35,240
how those two ice sheets have changed\h through time relative to each other.

71
00:06:35,240 --> 00:06:42,080
Harbeck: ICESat-2 has a 91-day repeat\h orbit cycle and a 92-degree inclination.

72
00:06:42,080 --> 00:06:46,240
ATL03 is one of the primary sources for\h all of the photon information required

73
00:06:46,240 --> 00:06:51,440
by higher-level data products, such as land\h ice height and sea ice freeboard.

74
00:06:51,440 --> 00:06:56,560
Neumann: As ICESat-2 transitions from taking data\h over land to collecting data over ocean,

75
00:06:56,560 --> 00:07:01,360
at times you'll notice we have a return off the\h ocean surface, but we also have a fainter second

76
00:07:01,360 --> 00:07:06,480
return. And that's due to photons penetrating\h down through the water column and reflecting off

77
00:07:06,480 --> 00:07:13,200
the seabed before returning to ICESat-2. In that\h way we're able to use ICESat-2 data to determine

78
00:07:13,200 --> 00:07:18,160
shallow water bathymetry around the planet.\h Determining bathymetry is not one of ICESat-2's

79
00:07:18,160 --> 00:07:22,400
primary objectives, but it is something the\h scientific community is very interested in.

80
00:07:22,400 --> 00:07:27,360
In very clear water, photons from ICESat-2\h can penetrate down through the water column,

81
00:07:27,360 --> 00:07:33,040
reflect off the ocean floor and travel back up\h to the spacecraft. By looking at our data so far,

82
00:07:33,040 --> 00:07:38,560
we note that ICESat-2 can measure up to 30\h meters of water depth, or nearly 100 feet. As

83
00:07:38,560 --> 00:07:43,680
the turbidity of water increases or there's more\h waves at the surface, we can only see very shallow

84
00:07:43,680 --> 00:07:49,760
water depths, perhaps just a few meters. Measuring\h bathymetry with ICESat-2 is one of the many things