

The ICESat-2 Inland Water Height Data Product: Overview and Evaluation Using High Altitude Lidar Observations

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Lehner Doll, GLWD, 2004

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Mission Summary

Instrument: Advanced Topographic Laser Altimeter System (ATLAS)

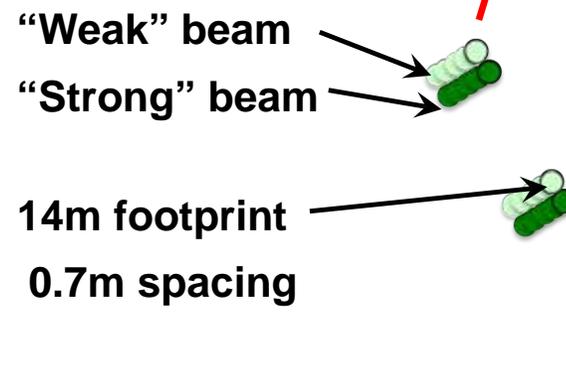
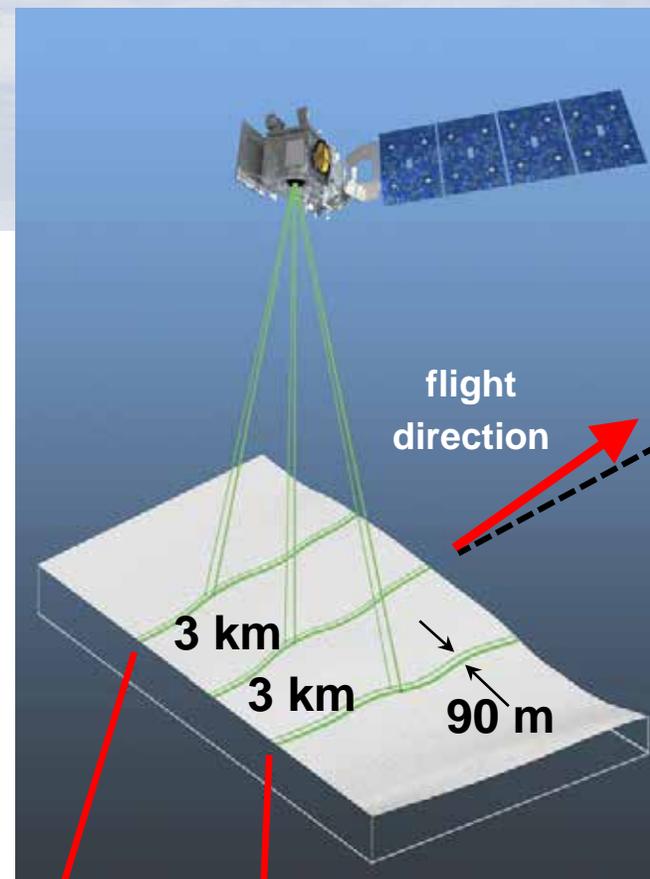
- Micro-pulse, single-photon detection
- 6 beams, 3 pairs of “weak/strong” (25, 100 μ J)
- 10 kHz pulse repetition rate
- 532 nm

Orbit: 500 km, non-sun-synch, 92° inclination

Repeat: 91 day, ~30 day subcycle

Launch: Sept. 12, 2018

Lifetime: 3 yrs, consumables for 7





ICESat-2 Data Products



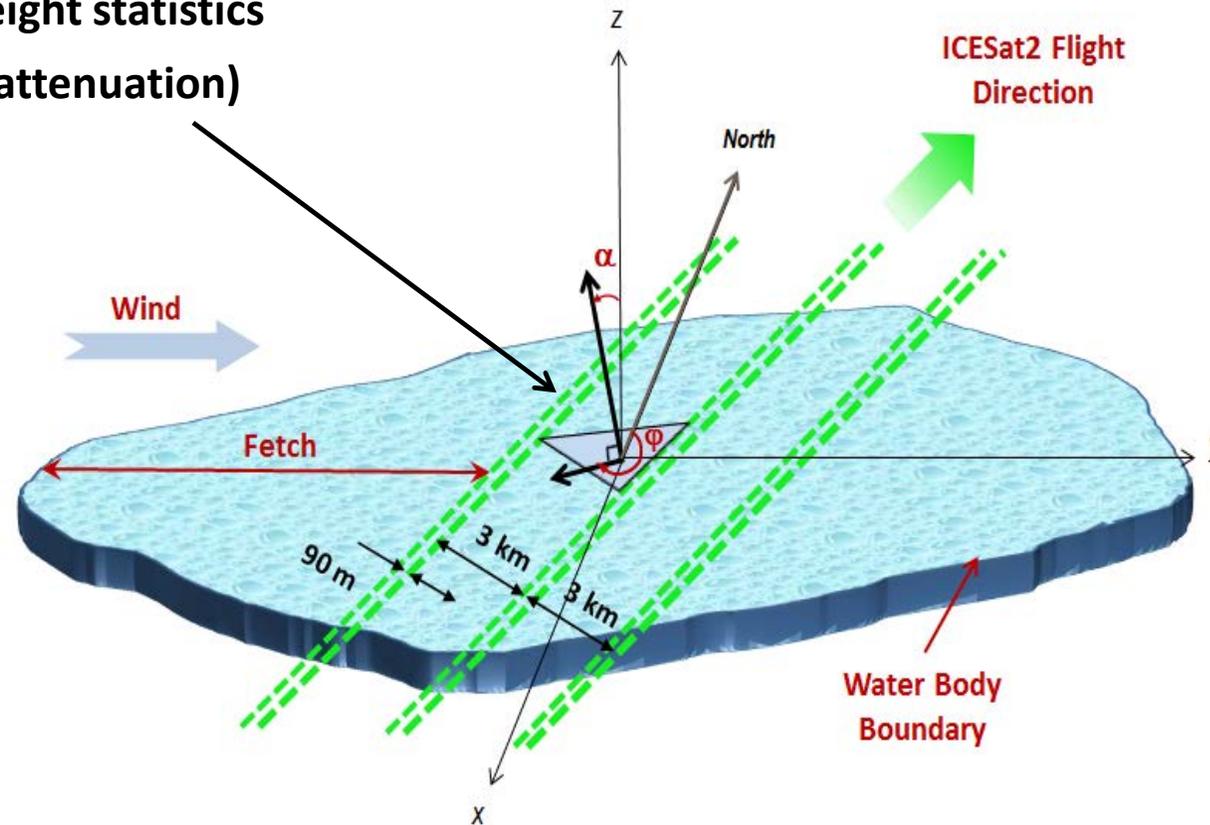
<u>ID</u>	<u>NAME</u>	<u>DESCRIPTION</u>
ATL03	Geolocated photons	Precise latitude, longitude and elevation for every received photon
ATL04	Uncalibrated Backscatter Profiles	Along-track atmospheric backscatter
ATL06	Land Ice Elevation	Surface height for each beam with along- and across-track slopes
ATL07	Arctic/Antarctic Sea Ice Elevation	Height of sea ice and open water leads at varying length scale
ATL08	Land and Vegetation Height	Height of ground including canopy surface & cover percentage
ATL09	Atmosphere Backscatter & Clouds	Along-track cloud and other atmosphere layer heights, blowing snow, optical depth.
ATL10	Arctic/Antarctic Sea Ice Freeboard	Sea ice freeboard @ specific spatial scales. Statistics of sea surface and sea ice heights.
ATL11	Antarctica / Greenland Ice Sheet Heights	Time series of height at points on the ice sheet,
ATL12	Ocean Elevation	Surface height at specific length scale, including height distribution
★ ATL13	Inland Water Height	Along-track inland and near shore water surface height distribution within water mask
ATL14	Antarctica/Greenland Ice Sheet H(t) Gridded	Height maps of each ice sheet for each year based on all available elevation data.
ATL15	Antarctica/Greenland Ice Sheet dh/dt Gridded	Height change maps for each ice sheet, for each mission year
ATL16	ATLAS Atmosphere Weekly	Polar cloud fraction, blowing snow frequency, ground detection frequency.
ATL17	ATLAS Atmosphere Monthly	Polar cloud fraction, blowing snow frequency, ground detection frequency.
ATL18	Land/Canopy Gridded	Gridded ground surface height, canopy height, and canopy cover estimates.
ATL19	Mean Sea Surface (MSS)	Gridded ocean height product.
ATL20	Arctic / Antarctic Gridded Sea Ice Freeboard	Gridded sea ice freeboard.
ATL21	Arctic/Antarctic Gridded SSH w/in Sea Ice	Gridded monthly sea surface height inside the sea ice cover.



ICESat-2 Inland Water Data Product

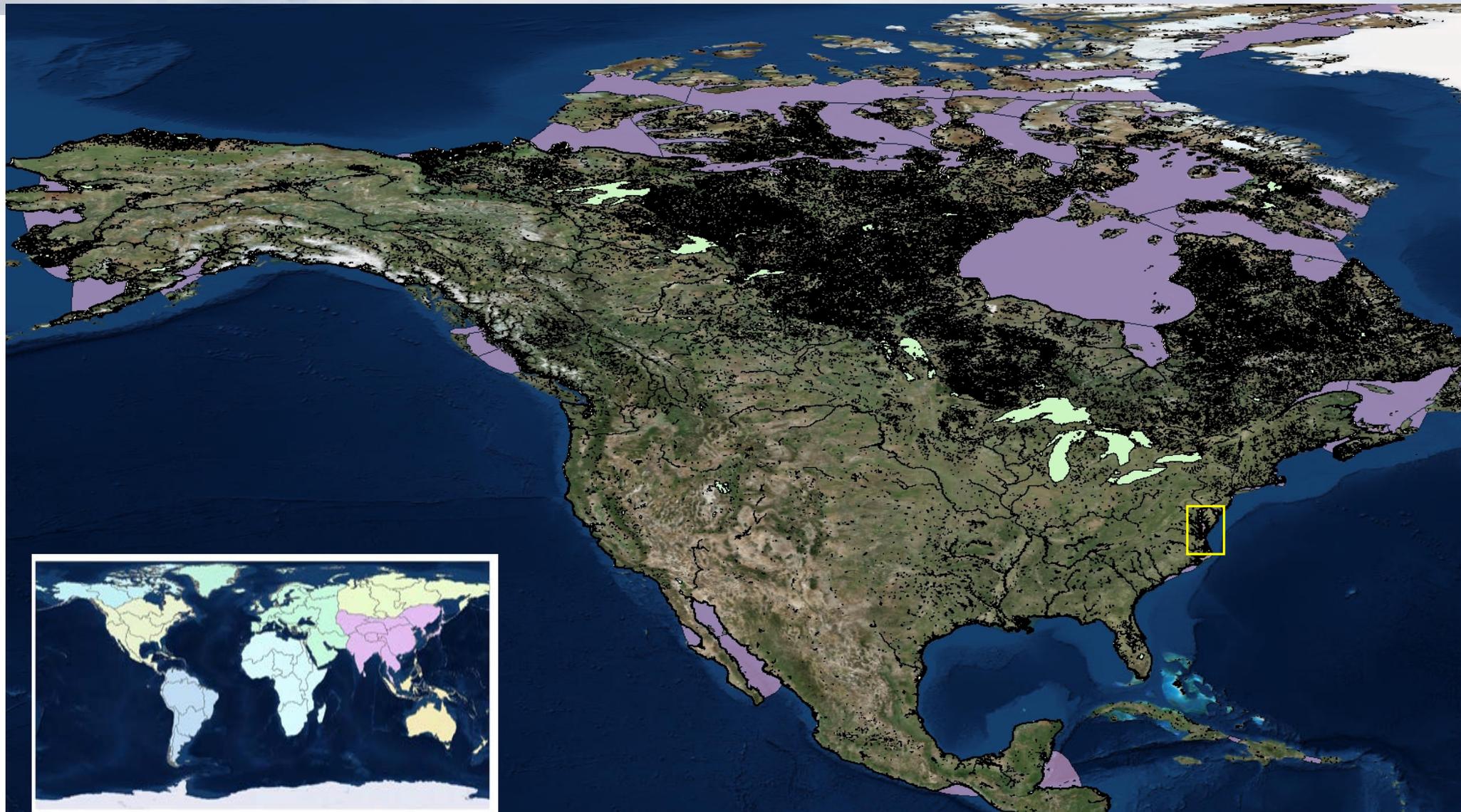


- Along track surface water height statistics
 Mean, SDev, subsurface attenuation)
- 100 photon segments
- Water bodies > ~ 5km²





ICESat-2 Inland Water Coverage





ICESat-2 Inland Water Coverage





ICESat-2 Observation Strategy: “Mapping” and “Repeat” Zones

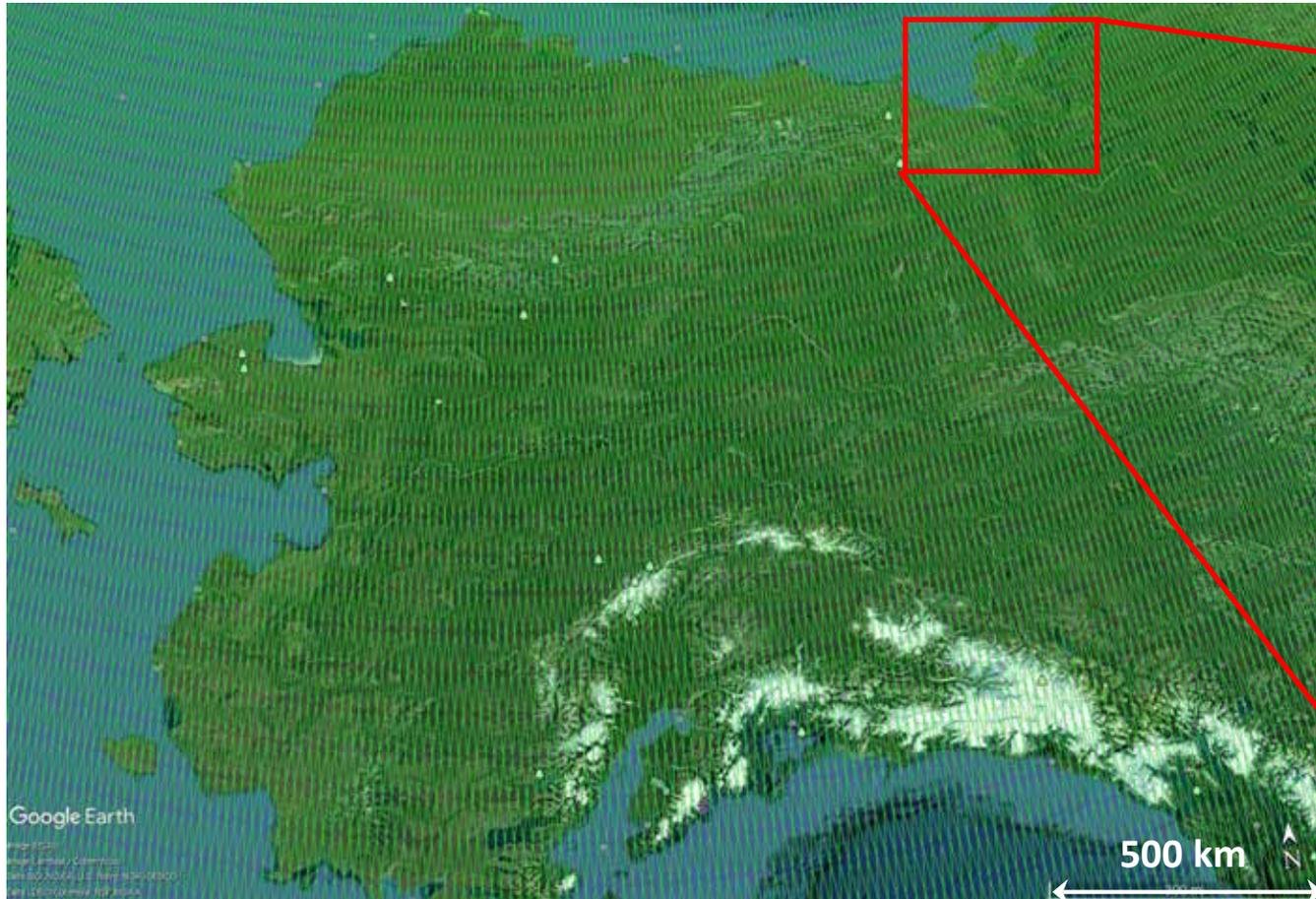




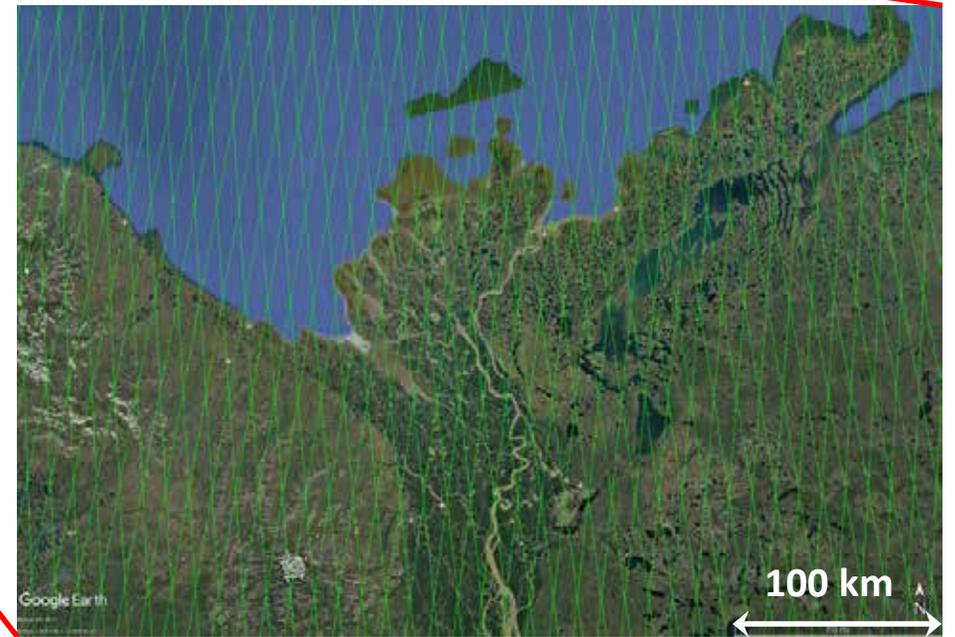
High Latitude Coverage



Alaska



Mackenzie River delta



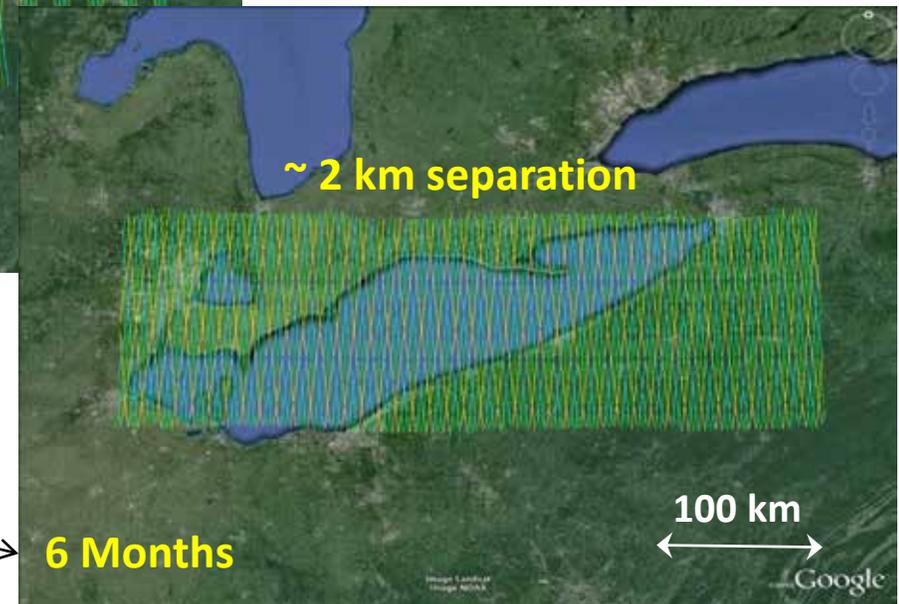
Typical 91-day pattern



Typical Orbits in Mid-Latitudes



E.g. Lake Erie, USA
25,700 km²
~42 deg N



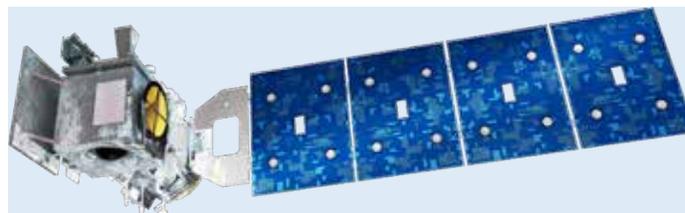
Months
after
launch



Testing ICESat-2 Inland Water Algorithm: Multiple Altimeter Beam Experimental Lidar (MABEL)



ICESat-2/ATLAS



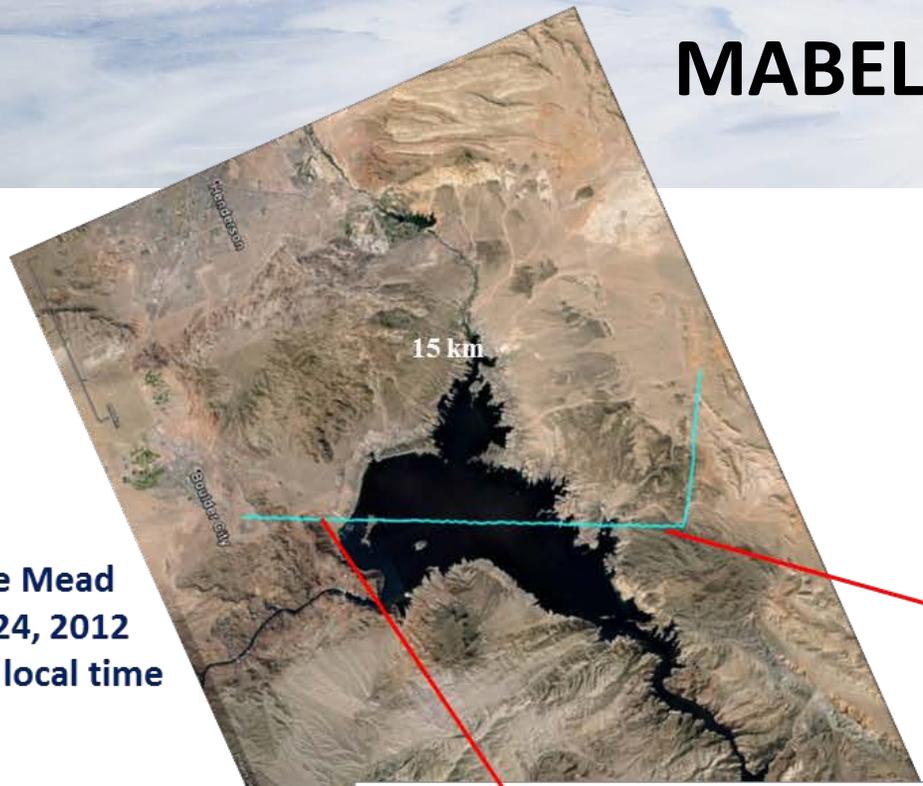
ER2/MABEL



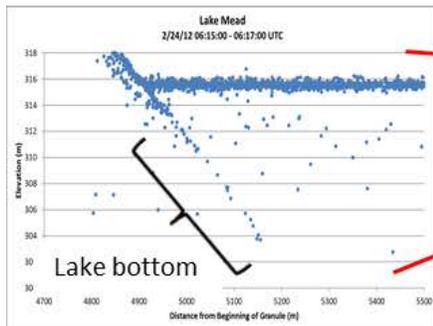
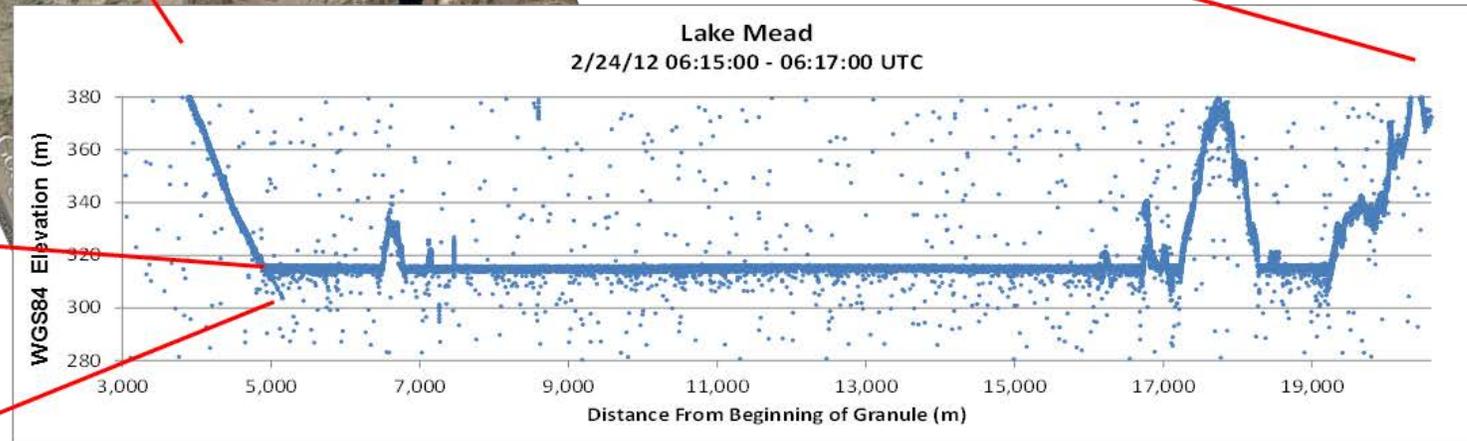
Operational altitude	600 km	20 km
Wavelength	532 nm	532 and 1064 nm
Telescope diameter	1 m	6 inches
Laser PRF	10 kHz	5 kHz
Laser pulse energy	25 μ J (weak) & 100 μ J (strong) beam	3-5 μ J per beam
Laser footprint diameter	17 μ rad (14 m)	100 μ rad (2 m)
Swath width	+/- 3 km	+/- 1.05 km



MABEL Experiment: Lake Mead

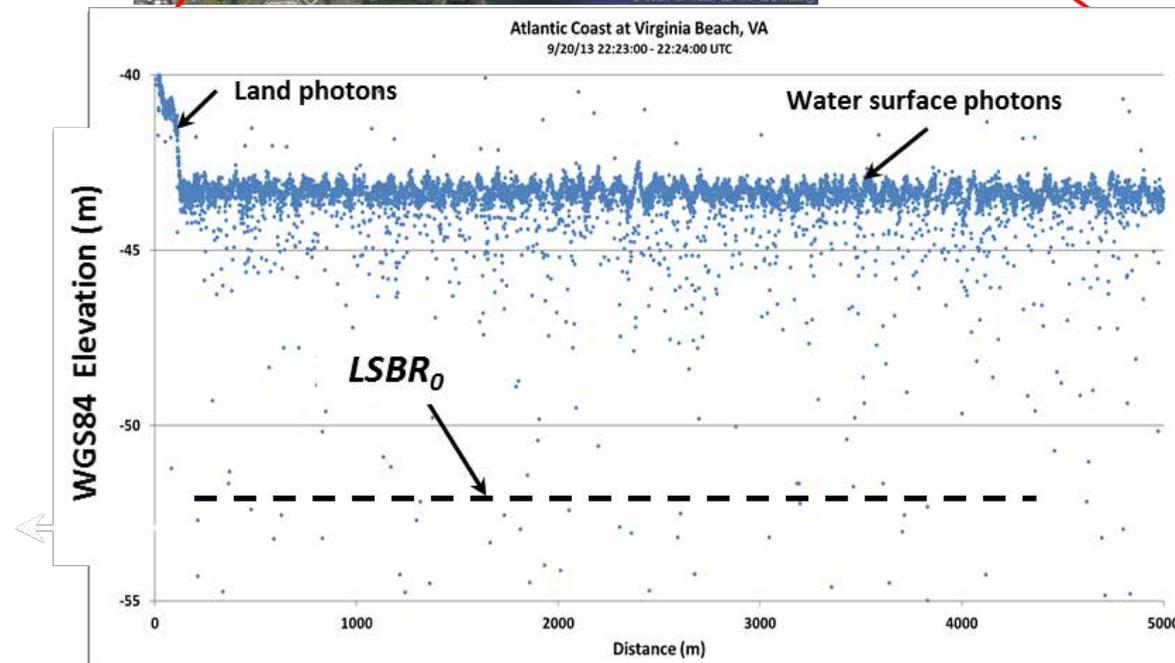
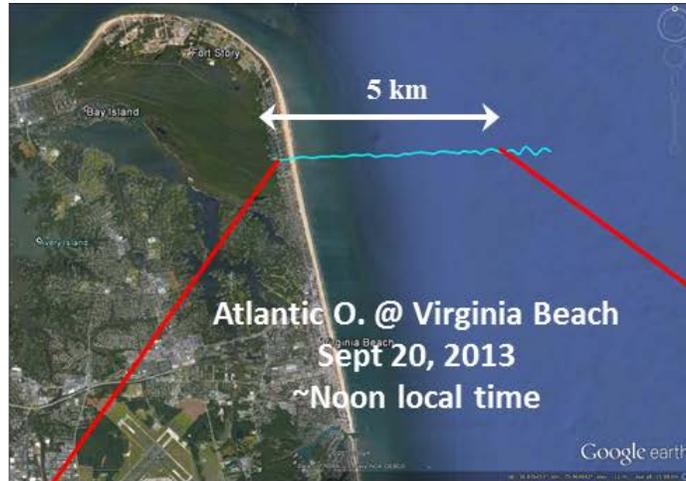


Lake Mead
Feb 24, 2012
11 PM local time



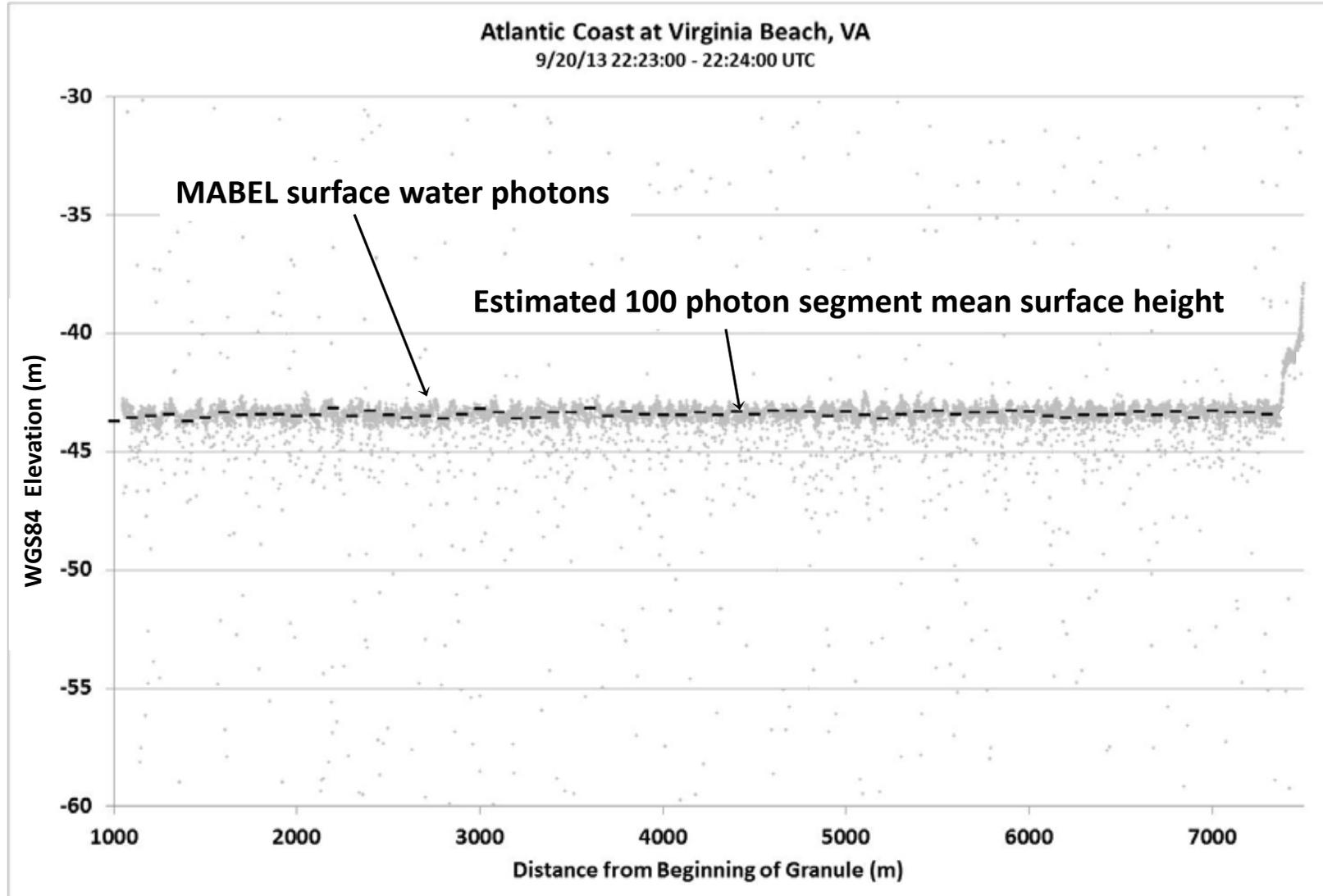


MABEL: Atlantic Coast near Virginia Beach





MABEL: Atlantic Coast near Virginia Beach





MABEL Summary



FLIGHT DESCRIPTIONS						
Site		Ches Bay	Ches Bay (mod bckgr)	Ches Bay (low bckgr)	VA Beach	Lake Mead
Year	-	2012	2013	2013	2013	2012
Date	-	Sep-22	Sep-25	Sep-25	Sep-20	Feb-24
Time	UTC	00:56-57	16:51-52	16:51-52	22:23-24	06:15-17
Local Time	-	20:56-57	12:51-52	12:51-52	18:23-24	22:15-17
IN-SITU OBSERVATIONS						
Sky Condition ^a	-	Clear	Partly Cloudy	Mostly Clear	Mostly Clear	Mostly Clear
Wind Speed	m/s	5.4 ^b	3.7 ^b	3.7 ^b	4.2 ^d	8.5 ^e
Wind Direction	Deg	162 ^b	41 ^b	41 ^b	93 ^d	27 ^e
Turbidity	NTU	3.9 ^c	2.9 ^b	2.9 ^b	2.2 ^d	1.6 ^f
Mean Water Surface	m	-	-	-	-	345.5 ^g
Signif. Wave Ht ⁱ	m	0.35	0.17	0.17	0.58	-
K ₅₃₂ , Diff. Attn. Coef.	m ⁻¹	-	0.45 ^p	0.52 ^p	-	-
DERIVED WATER CHARACTERISTICS FROM MABEL OBSERVATIONS						
Background Rate ^m	m ⁻²	0.00002	0.011	0.0053	0.0003	0.00008
Water Signal Rate ⁿ	m ⁻²	0.36	0.56	2.20	0.41	2.9
LSBR ₀ Depth ^k	m	-6.8	-1.3	-3.7	-9.3	-9.2
Water Surface St Dev ^l	m	0.11	0.088	0.065	0.21	0.14
Mean Geodetic Ht ^h	m	-36.8	-40.0	-40.0	-43.2	315.9
Mean Orthom Ht ⁱ	m	-1.4	-4.6	-4.6	-3.6	344.8
Height Precision	cm	5.0	4.0	2.0	4.7	1.8
α ₅₃₃₂ , Subs. Attn. Coef.	m ⁻¹	0.69	0.91	0.56	0.55	0.40
α ₅₃₃₂ x LSBR ₀ (mean = 3.3)	-	4.7	1.3	2.1	5.1	3.4

Jasinski et al., 2016.
J. Coastal Research





CAL/VAL and Monitoring



Strategy

- 1. Monitor lakes currently included in global lake databases, e.g.**
 - G-REALM (230)
 - Globolakes (960)
 - HYDROWEB (100)
 - Other well monitored lakes & lake databases
(E.g. Issyk-Kul, Great Lakes, Tahoe, Mead)
- 2. CAL/VAL collaborating w/already planned field experiments**
 - Arctic Lakes Ice Systems Science (ALISS)
 - Arctic-Boreal Vulnerability Experiment (ABOVE)
 - USGS Coastal National Elevation Database (CoNED)
 - Arctic Coastal Land Interactions (COLORS)



Alaska CAL/VAL

- Lake Teshekpuk
- Inigot
- Toolik Lake
- Yukon River delta
- Mackenzie River delta
- Lake Tazlina



Conclusions



- 1. Global ICESat-2 Inland Water Height Data Product is under development**
- 2. Tested using high altitude MABEL observations**
 - precision of ~5 cm/100 m segments under clear skies
- 3. CAL/VAL and monitoring:**
 - Comparison with existing global lake databases
 - Leveraging off existing & planned field experiments
 - looking for collaborations.....



Thank You!

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<https://icesat.gsfc.nasa.gov/>

<https://icesat-2.gsfc.nasa.gov/>

