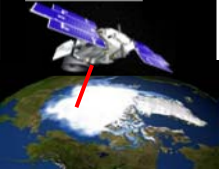


The ICESat-2 Mission
Laser altimetry of ice, clouds and land elevation

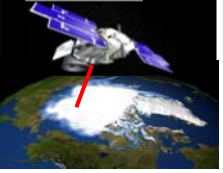
…and also ocean, coastal, and continental waters

Charon Birkett, ESSIC/UMD

on behalf of

T. Markus, T. Neumann, Project and Deputy Project Scientists
NASA Goddard Space Flight Center

And the ICESat-2 SDT "Water Team"



ICESat-2 Mission Concept

In contrast to ICESat design, ICESat-2 will use ***micro-pulse multi-beam photon counting*** approach.

Provides:

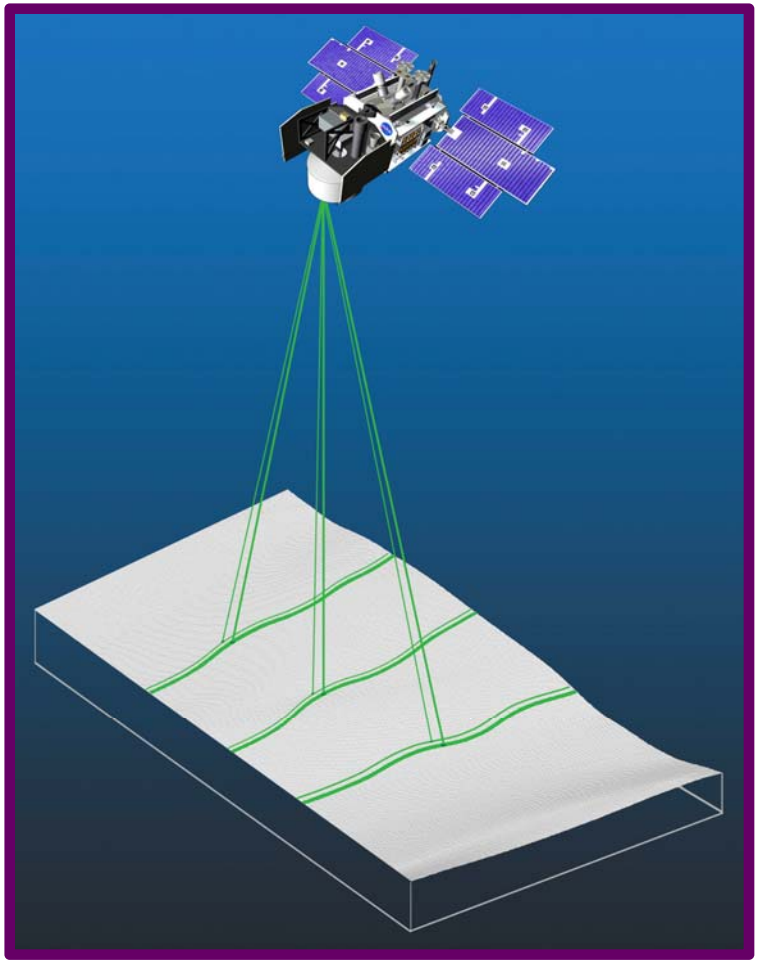
Dense cross-track sampling to resolve surface slope on an orbit basis.

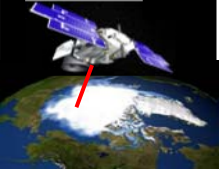
High repetition rate (**10 kHz**) generates dense along-track sampling (**~70 cm**).

Different beam energies to provide necessary dynamic range (bright / dark surfaces).

Advantages:

Improved elevation estimates over high slope areas and very rough (e.g. crevassed) areas
Improved lead detection for sea ice freeboard.





Analog –vs- Photon-Counting

laser pulse
(incident photons)

Threshold

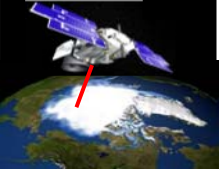
Apply arbitrary threshold; anything above the threshold is something, everything below the threshold is nothing.

Analog approach
(digitized waveform)

Photon-counting sampling
(single pulse)

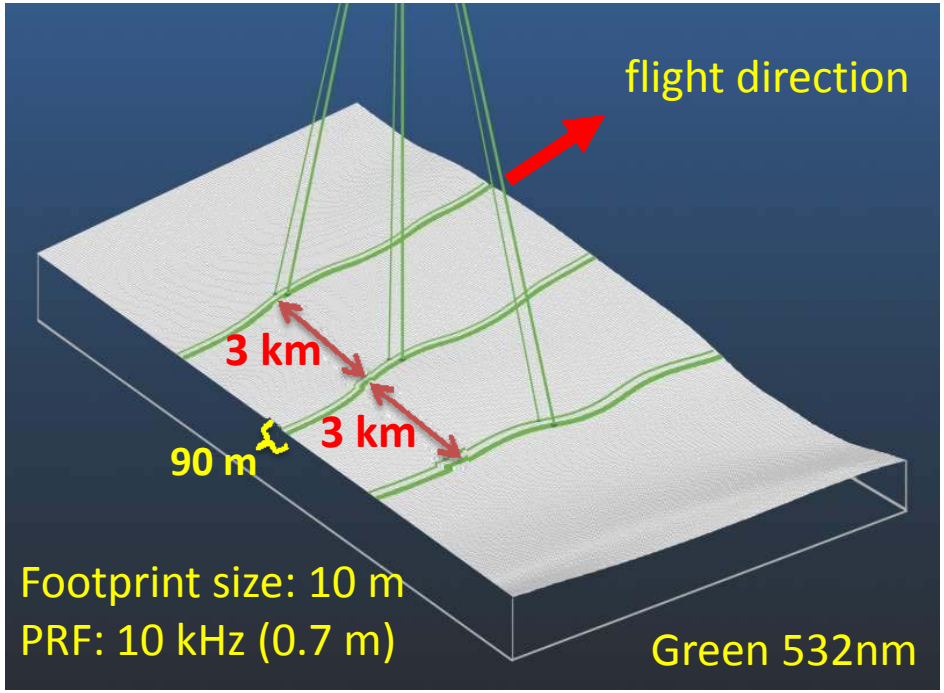
Photon-counting sampling
(integrated pulses)

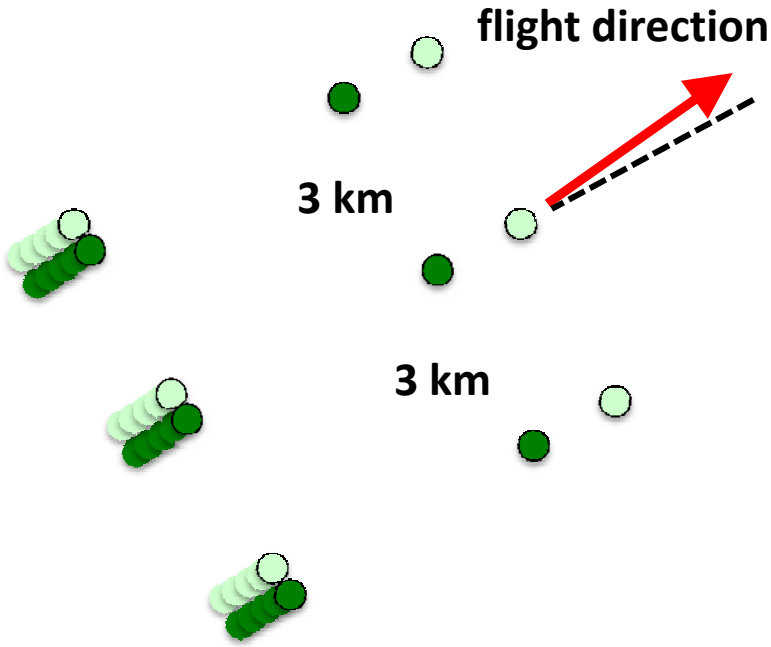
IMPORTANT: the integrated photon-counting sample ("histogram") *looks* like the analog waveform, but *it is not* – the information content is different, and the method of analyzing the data is different.



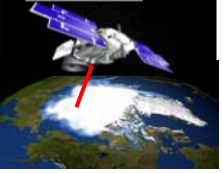
ATLAS – Advanced Topographic Laser Altimeter System

3. Number of beams.





3 km spacing between pairs provides spatial coverage
90 m pair spacing for cross-track slope determination (2 degrees of yaw)
high-energy beams (4x) for better performance over low-reflectivity targets

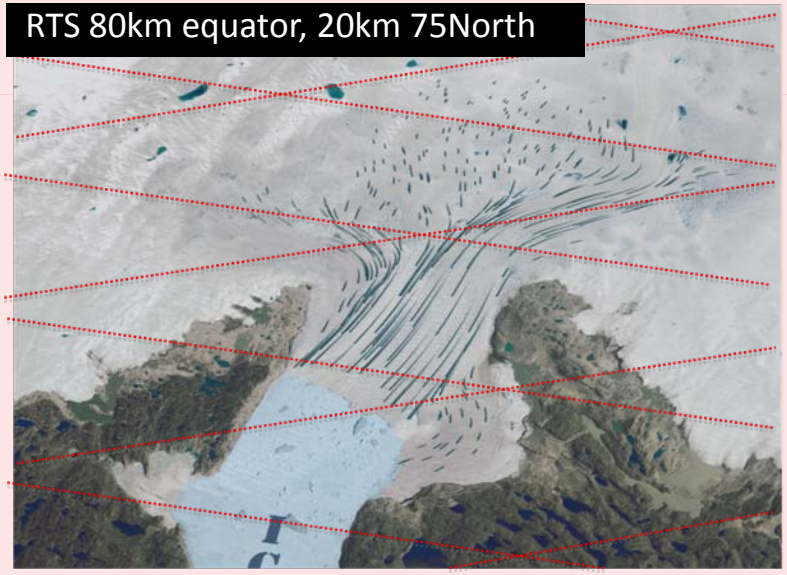


ICESat-2 latest developments

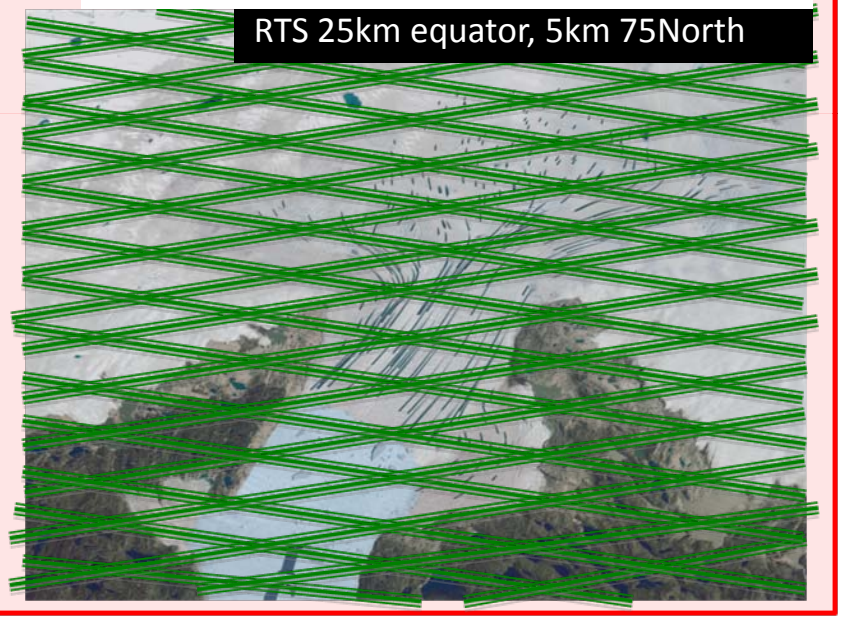
Mission Launch and duration 2016, 3 years with a 5-year goal.

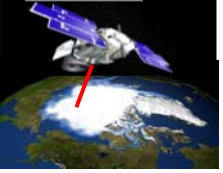
Nominal orbital altitude: 496 km, Inclination still under discussion (94deg?)
91-day exact repeat, Subcycles: 29-29-33 days
1387 revolutions, coverage to 86deg lat, not sun synchronous

Orig ICESat-1 coverage over Jakobshavn glacier.



ICESat-2 coverage over Jakobshavn glacier.





Science Requirements

LAND ICE: Ice-sheet elevation changes to 0.4 cm/yr accuracy on an annual basis.
Annual surface elevation change rates on outlet glaciers to better than 0.25 m/yr over areas 100 km^2 for year-to-year averages.
Surface elevation change rates to an accuracy of 0.4 m/yr along 1 km track segments for dynamic ice features that are intersected by the ICESat-2 set of repeated ground-tracks.
Resolution of winter (accumulation) and summer (ablation) ice-sheet elevation change to 10 cm at 25 km x 25 km spatial scales.

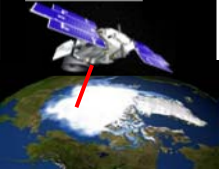
SEA ICE: Monthly surface elevation measurements with a track density of better than 30 km poleward of 70 degrees, to enable the determination of sea ice freeboard when sea surface references are available, under clear sky conditions, to an uncertainty of 3 cm along 25 km segments, for the Arctic Ocean and Southern Oceans.

VEGETATION: ICESat-2 shall produce elevation measurements that enable determination of global vegetation height to 3-m accuracy at 1-km spatial resolution in vegetated area with canopy closures less than or equal to 75 percent under clear sky conditions.

SURFACE WATERS: No Science Requirements

Ocean conical scans considered for pointing accuracy studies (as per ICESat-1).
Design case studies considering the 5degree scans,0.25 optical depth, averaging 100 shots, suggest:
1.3cm/0.7cm stdev range (weak/strong beams with SWH 0.1m), -0.25cm range bias
22.3cm/13.6cm stdev range, (weak/strong beams with SWH 4m), 26cm range bias
Range precision improves with strong beam and calmer surfaces.

Satellite orbit 4cm (LRS, GPS), Atmosphere (Wet – model) 3cm, Range Precision 1-22cm
Expected Accuracy? 5-20cm, averaging 100shots (70m) along track. Expected improvement for near nadir shots.



Interest to OSTM/SWOT/Coastal

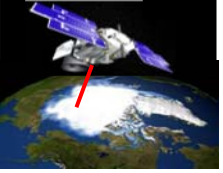
Laser Operating over all Surfaces – Cloud limitations but very high spatial resolution, small footprint, mapping/monitoring capabilities, combined radar/lidar advantages with synergistic radar altimeters.

Ocean: 91-day exact repeat, subcycle: ~30day

Vegetation/Land: Offpointing to fill in ground tracks (drift)
Non-repeat tracks
May operate via series of masks
Probably between 50South – 50North
Very much TBD

Continental Waters: TBD
High North +South lats - 91-day repeat
Mid/Low lats – non-repeat or mix of both.

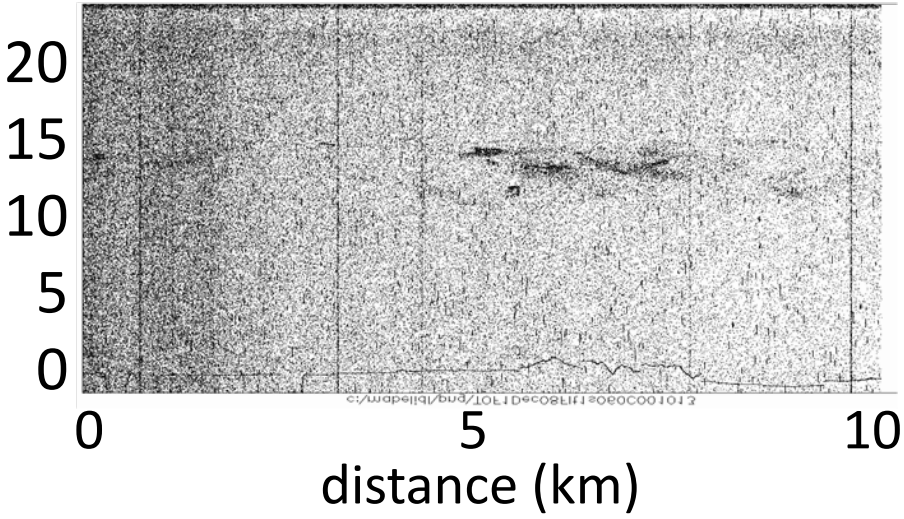
Coastal Ocean: Ocean scenario but depends on Vegtn mask limits



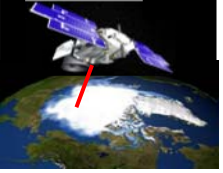
MABEL: The ICESat-2 simulator

- serves as instrument demonstrator
- allows verification of instrument models
- simulation of spaceborne measurement
- assessment of atmospheric effects
- provides data for algorithm development

16 footprints in green (532nm)
8 footprints in red (1064 nm)
adjustable rep. rate (5 to 25 kHz)
footprint pattern adjustable between flights



Rides on the ER-2 at 65,000 ft (above ~95% of atmosphere) → 2m diameter footprints.
At nominal cruise speed of 200 m/s at 10 kHz fire rate → footprint every 2 cm (!).
Flights from Dec 2010. Fresh water lakes, coastal oceans, land data available. Polar oceans in 2012.



ICESat-2 Information

Thomas Wagner, Program Scientist
Thorsten Markus, Project Scientist
Tom Neumann, Deputy Project Scientist (thomas.neumann@nasa.gov)

Web sites
http://icesat.gsfc.nasa.gov/icesat2
http://icesat.gsfc.nasa.gov/icesat2/mabel.php
http://nsidc.org/data/icesat (Latest reprocessed ICESat-1 data products)

New ICESat-2 Science Definition Team – results expected Nov 2011.
Water Team discussing Data Levels/Products/Regional Masks/MABEL
Participation from OSTM/SWOT/Coastal communities encouraged.

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Myself (cmb@essic.umd.edu), Mike Jasinski (michael.f.jasinski@nasa.gov)