Advances in Seafloor Mapping with New Spaceborne and Airborne Lidar Systems

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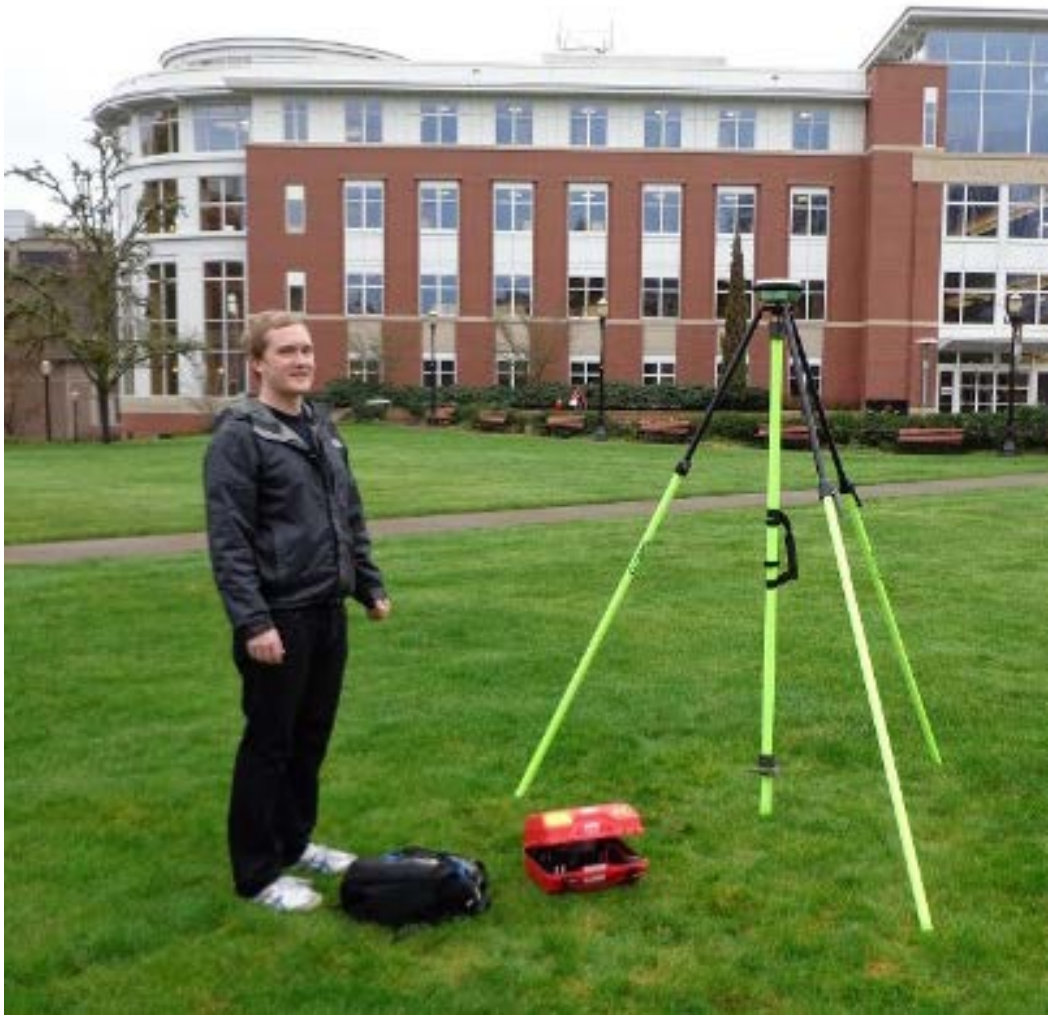
17th Annual JALBTCX Airborne Coastal Mapping and Charting Workshop

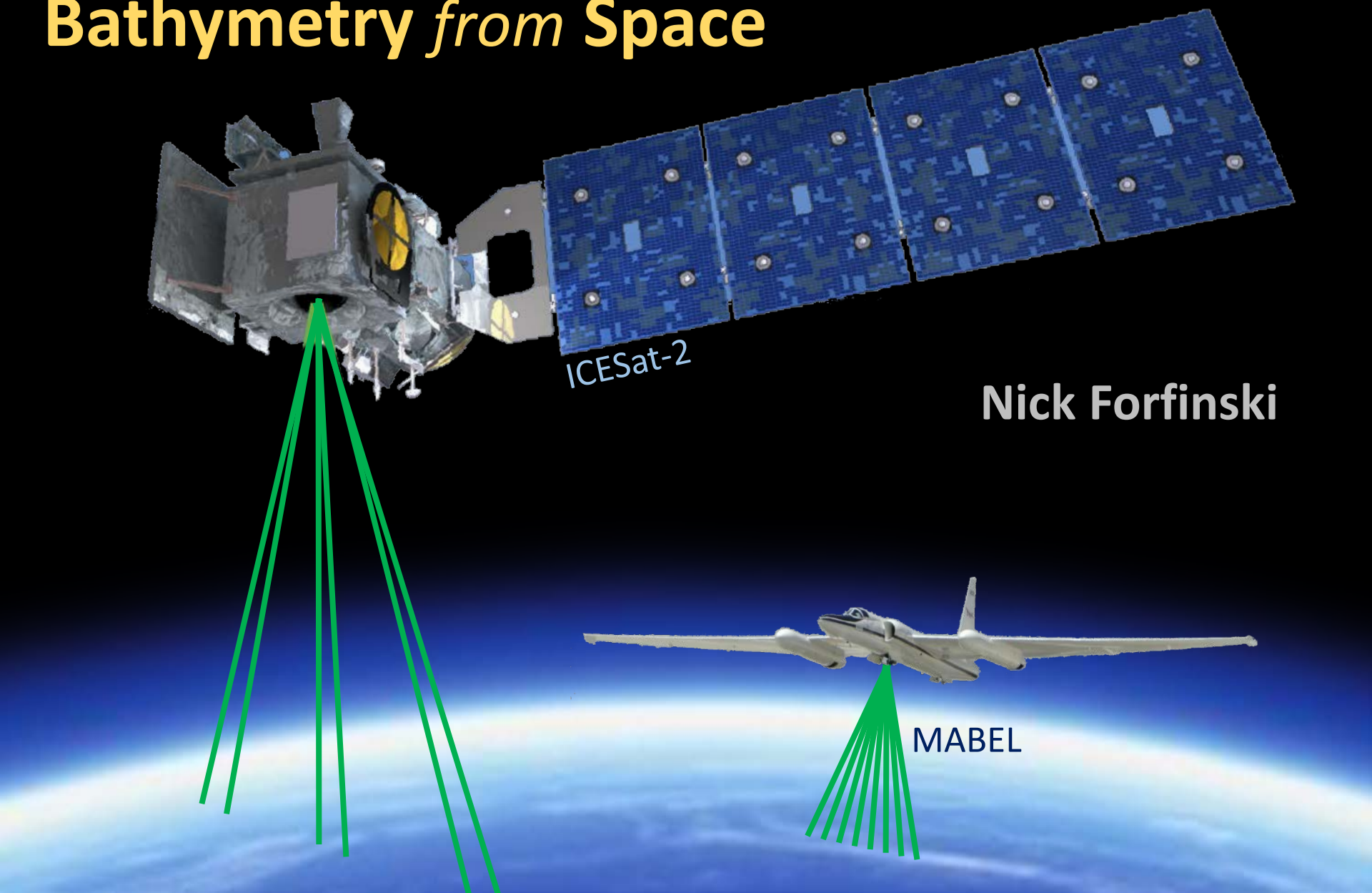
7/20/2016

Nick Wilson (Nick #1)



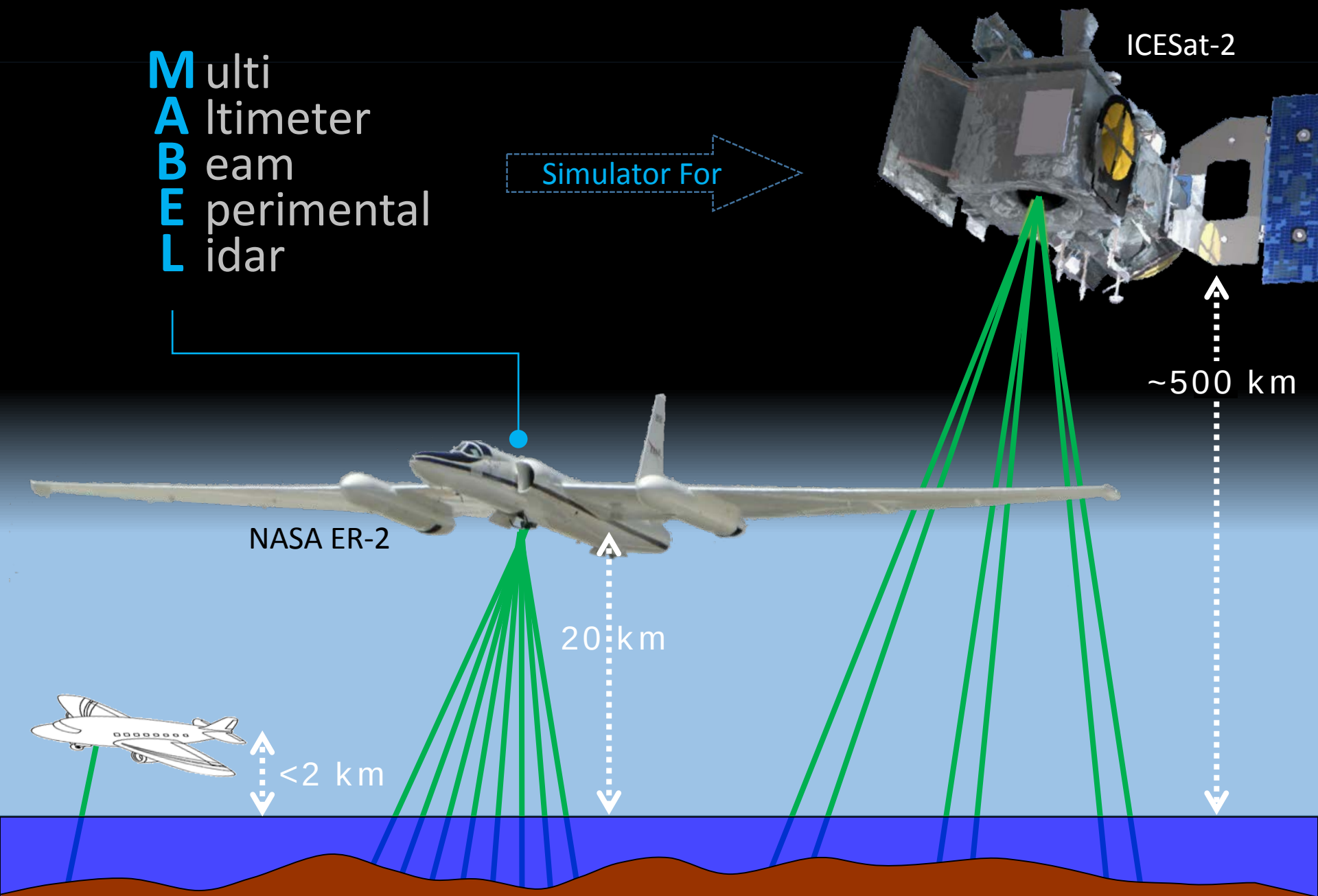
Nick Forfinski (Nick #2)

Assessing *the* Feasibility *of* Measuring Bathymetry *from* Space

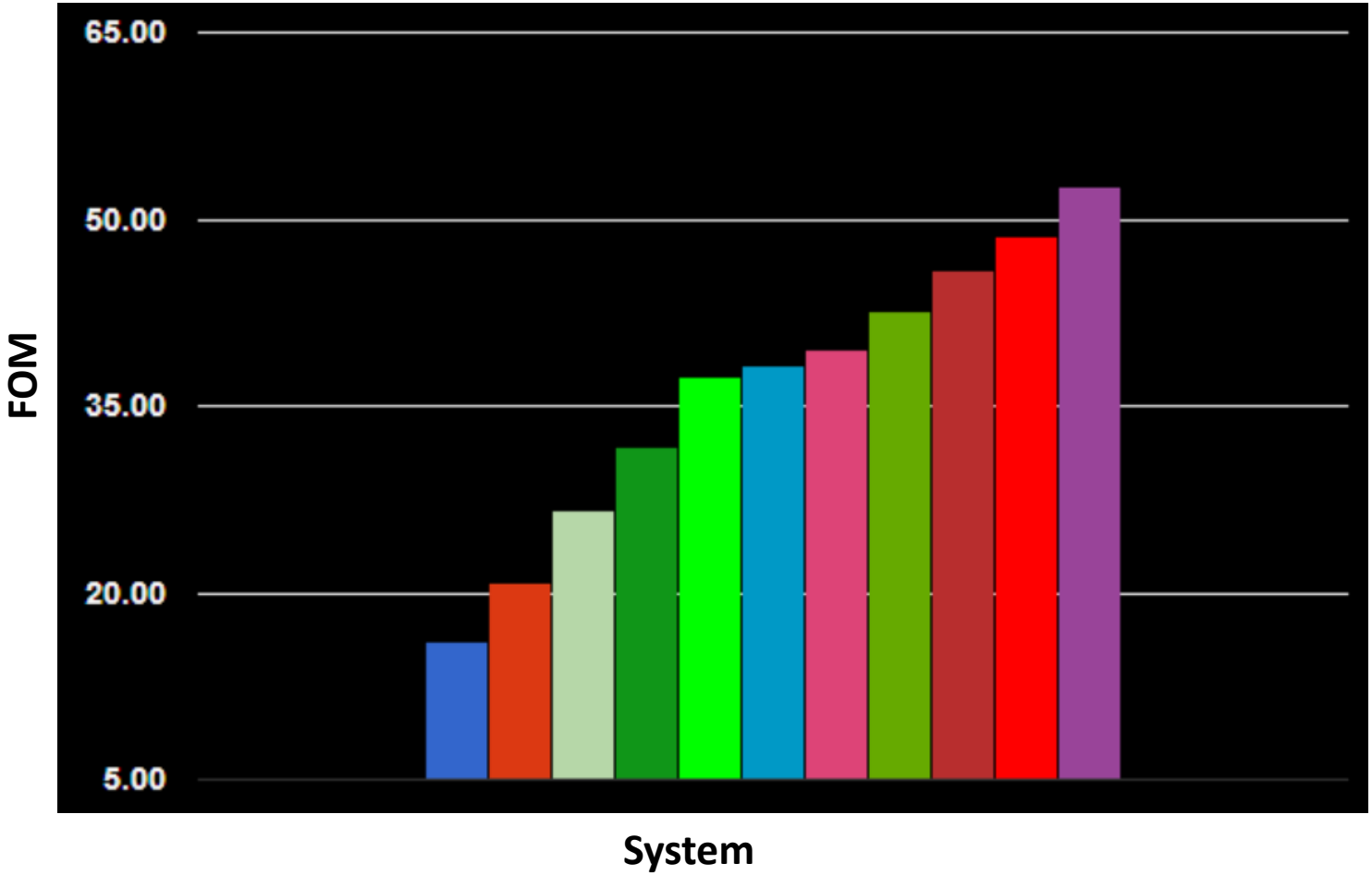


Nick Forfinski

BATHY from Space! *(maybe)*



Wright-Feygels Bathymetric Lidar System Figure of Merit:

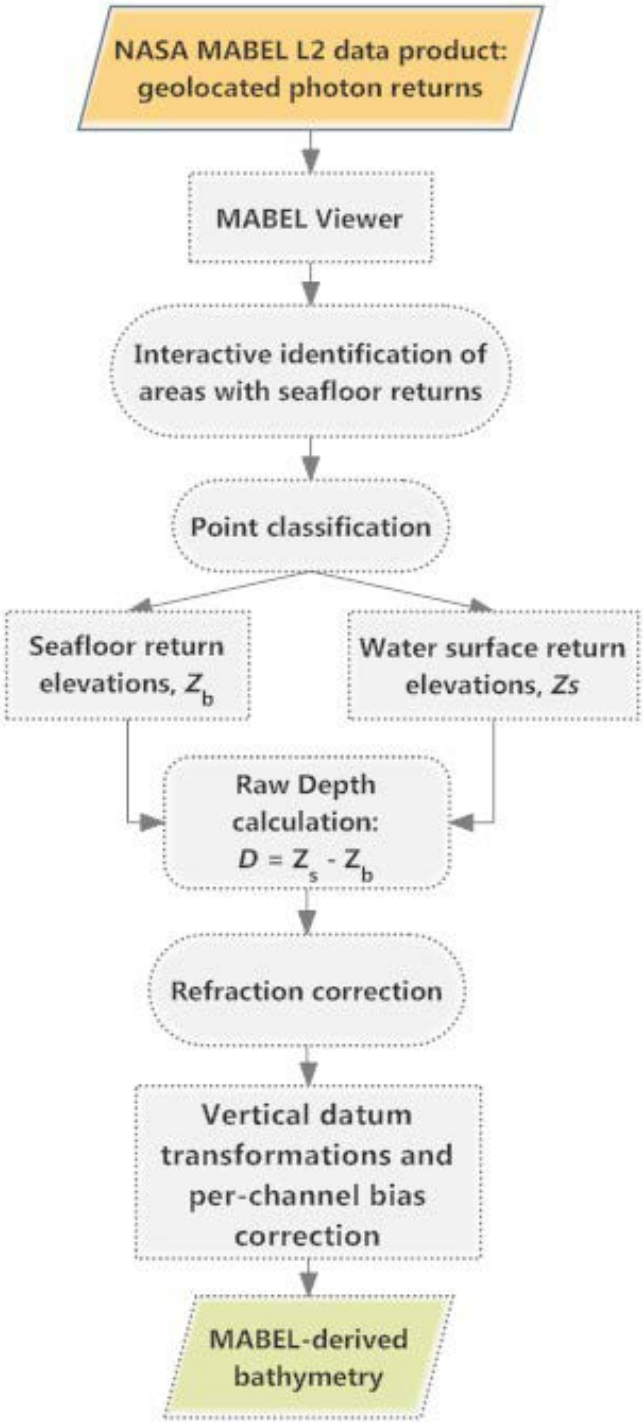


Wright, W., and N. Johnson, 2015. National Coastal Mapping Strategy - Bathymetric Lidar Quality Levels Introduction and Discussion, JALBTCX National Coastal Mapping and Charting Workshop, 17 June, Corvallis, OR

So, why do we care?

1. Repeat passes (ICESat-2: 91-day repeat orbit, 30-day sub-cycle)
   - Lots of possible attempts to catch area at a time of good water clarity
   - Ability to map remote/inaccessible coastal areas
   - Facilitates change analysis
2. Data can be synergistically fused with data obtained from passive, multispectral satellite imagery
   - Bathymetry from MABEL or ATLAS
     - Direct depth measurement
     - Does not require “seed” depths
     - Relatively sparse measurements, constrained to lie along track lines
   - Bathymetry from multispectral satellite imagery
     - Good spatial coverage
     - Requires seed depths

MABEL bathymetric mapping workflow



MABEL Viewer

File Menu

Function Buttons

- Recent Places
- Libraries
  - Documents
  - Music
  - Pictures
  - Videos
- Computer
  - OSDisk (C:)
  - shared (\\depot.engr.oregonstate.edu\cce_
    - CEM263 - Nick Share
    - Forfinski_Share
      - ICESat-2 Forfinski Share
        - MABEL_data
          - Land_Ice_1
          - Pole_Return
          - Sea-Ice-1
            - 1924
          - Vegetation_1
          - Vegetation_Day_Flight_2
          - Water_Targets_mission
        - Matlab_code
        - Presentations
        - Proposal
        - References
    - Gillins share
    - Nick_Wilson_Project
    - SwathNormalizeTool
    - USVI EAARL-B Reflectance Mapping
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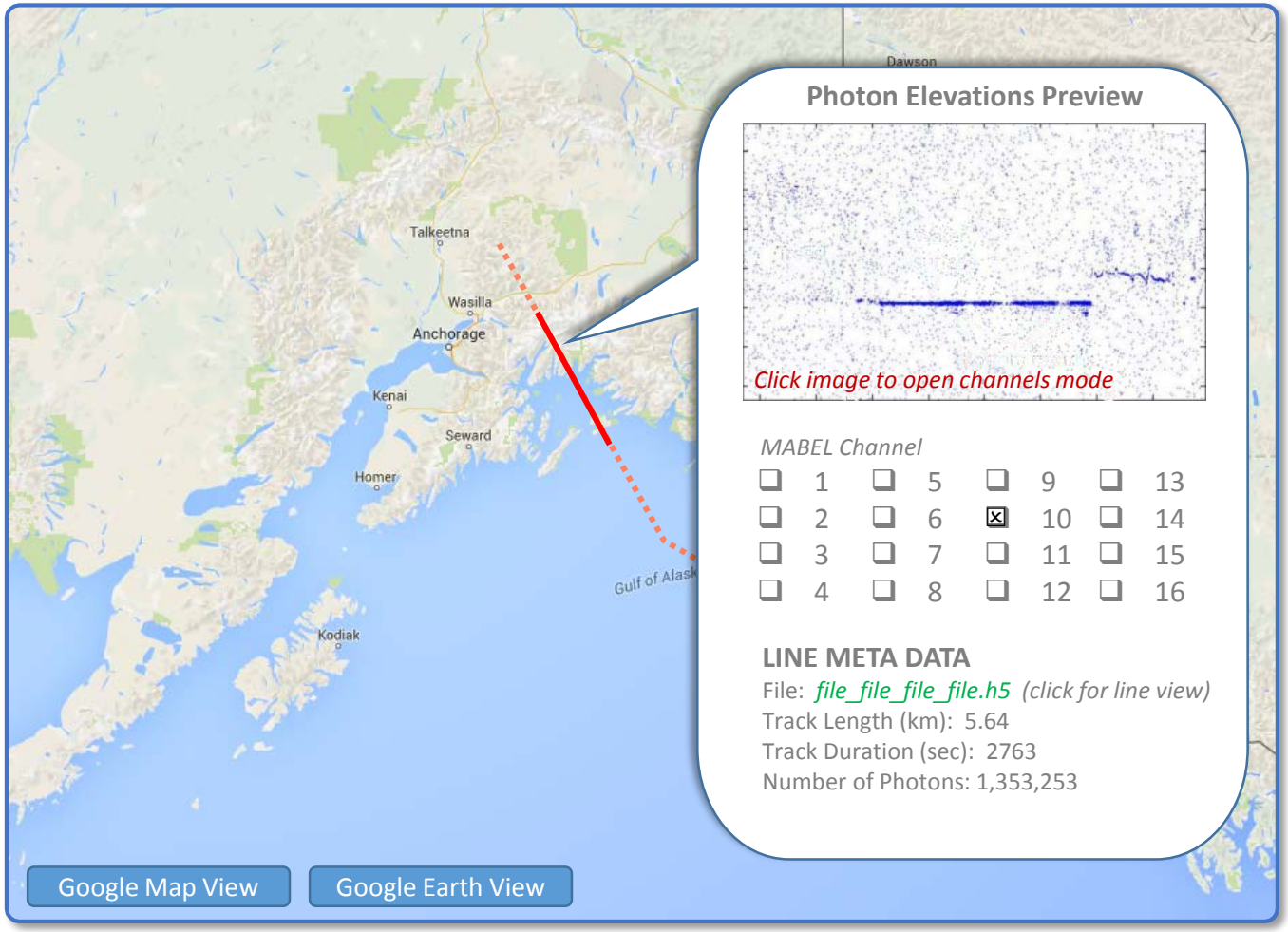

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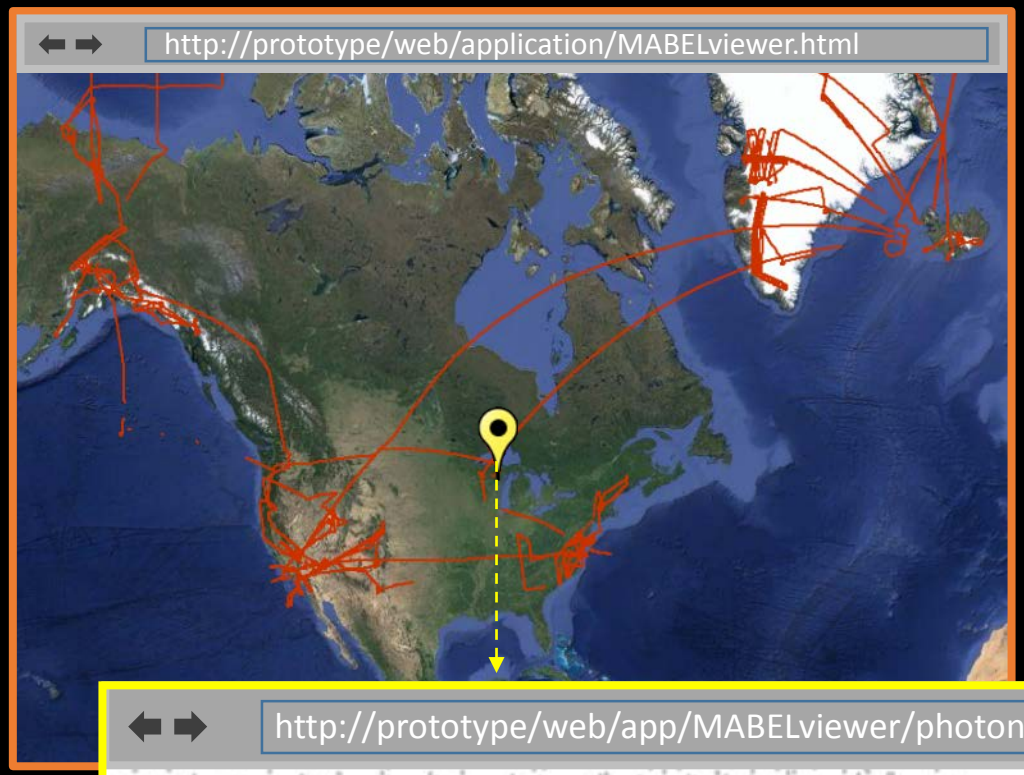
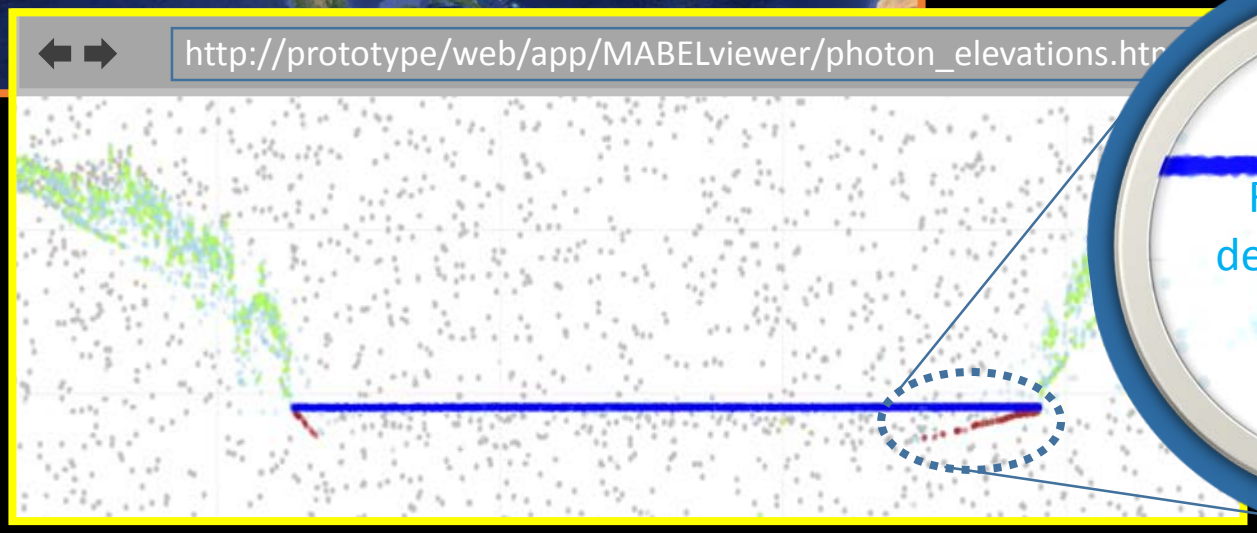
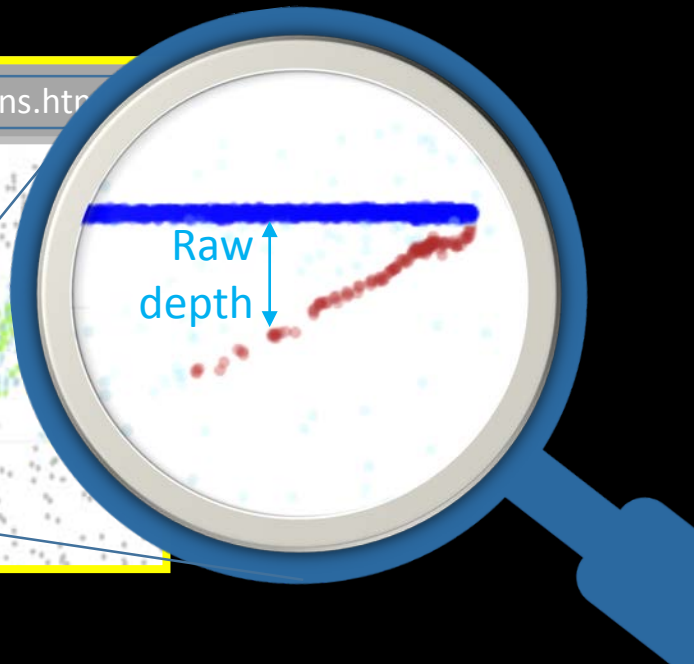
How to assess feasibility of using ICESat-2 to get bathymetry?

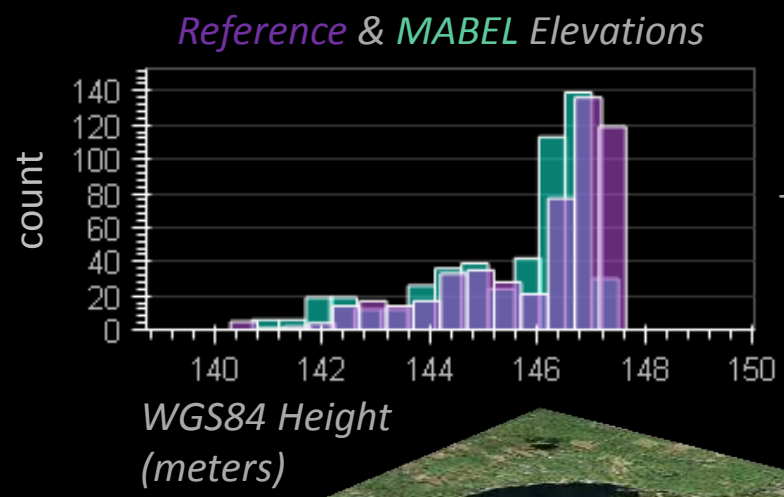


- Look for examples of detected bathymetry in MABEL data (using MABEL Viewer)
- Use LIDAR equation to calculate theoretical returns from MABEL (& ICESat-2)

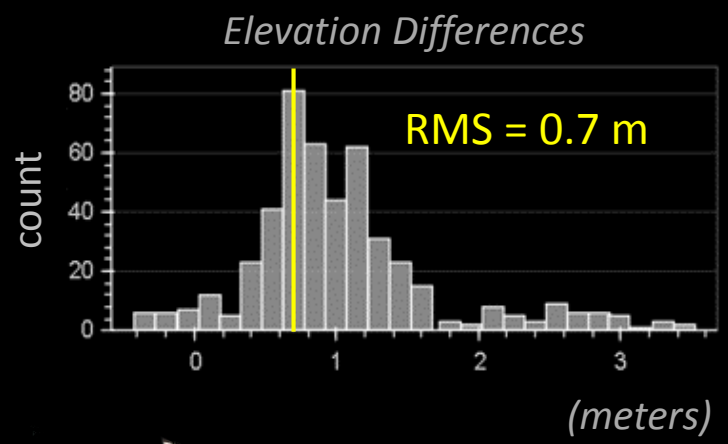


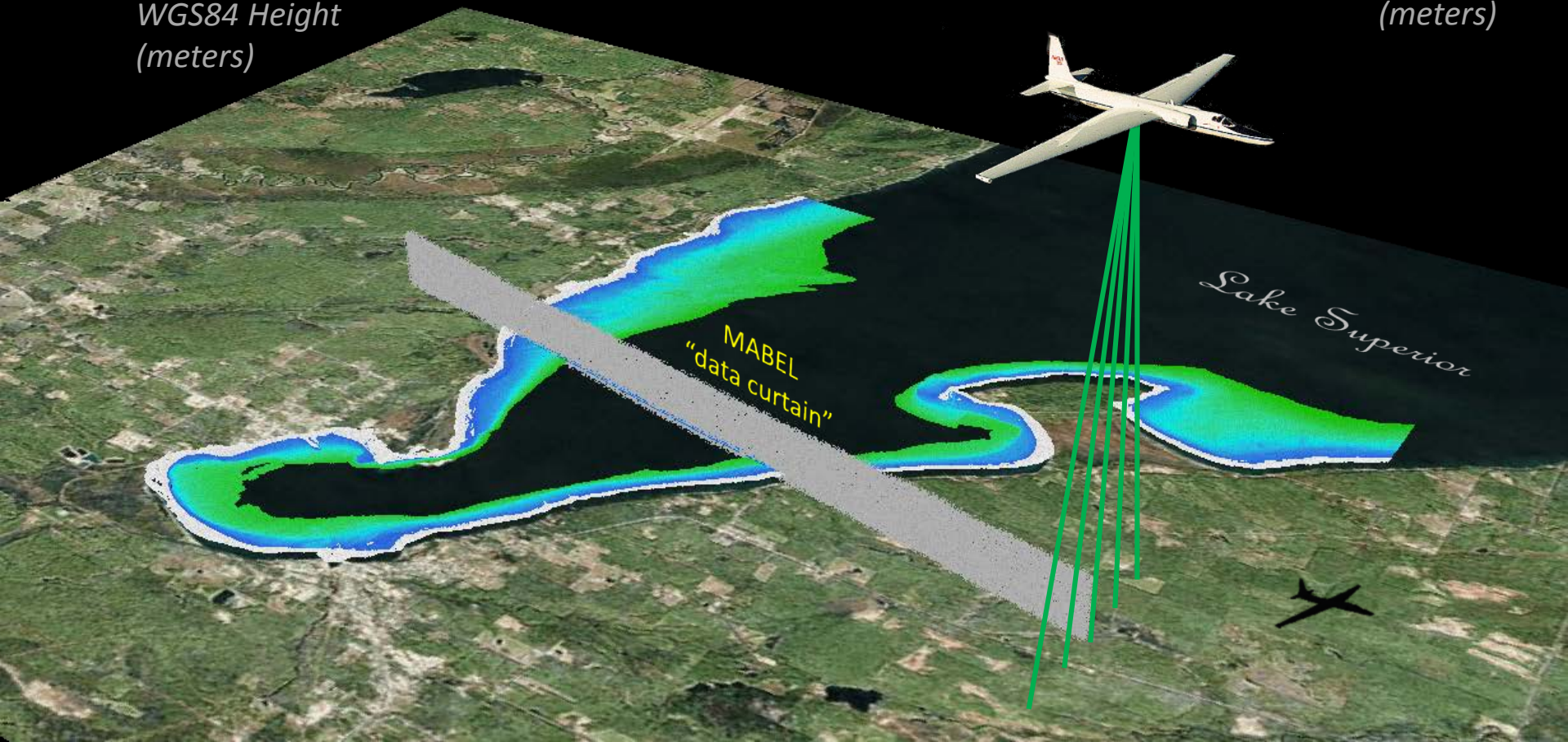


Comparison with Existing NOAA Bathymetry



difference the histograms →



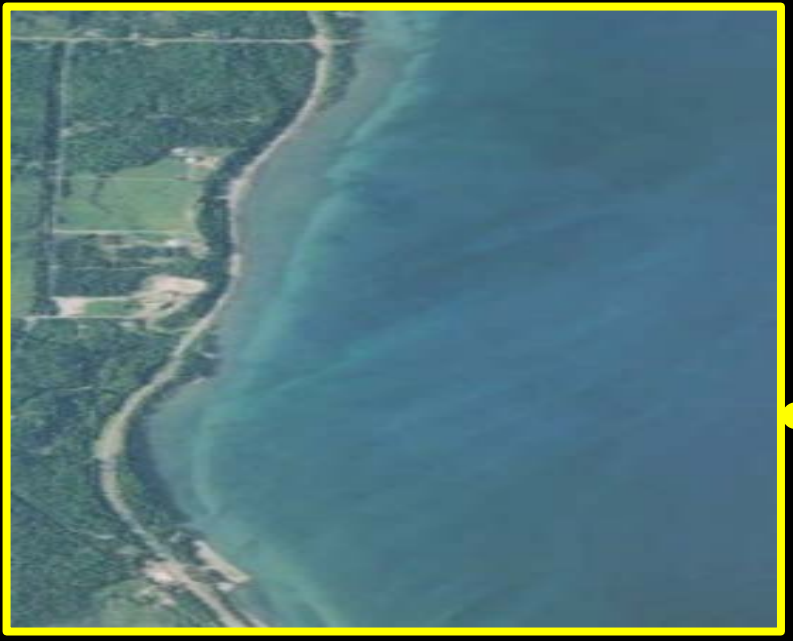


Comparison of MABEL and planned ATLAS system parameters

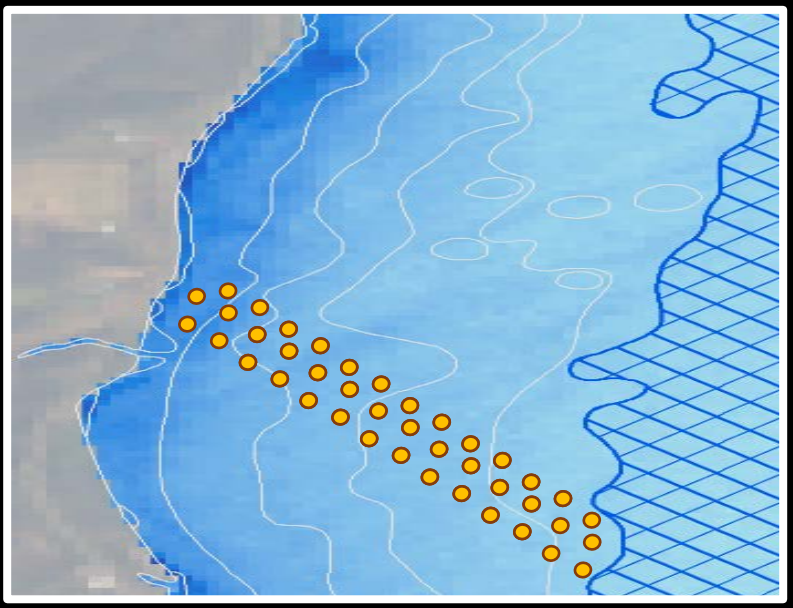
Parameter	MABEL	ATLAS
Footprint	2 m	12 m
Laser pulse repetition freq.	5-20 kHz	10 kHz
Pulse Energy	5-7 μJ	25 μJ
Pulse pattern	16 532-nm beams, 8 1054-nm beams	6 beams (3 pairs of 2)
Wavelength	532 and 1064 nm	532 nm
Receiver aperture area	0.013 m^2	0.79 m^2
Operational Altitude	20 km	500 km

Future Research:

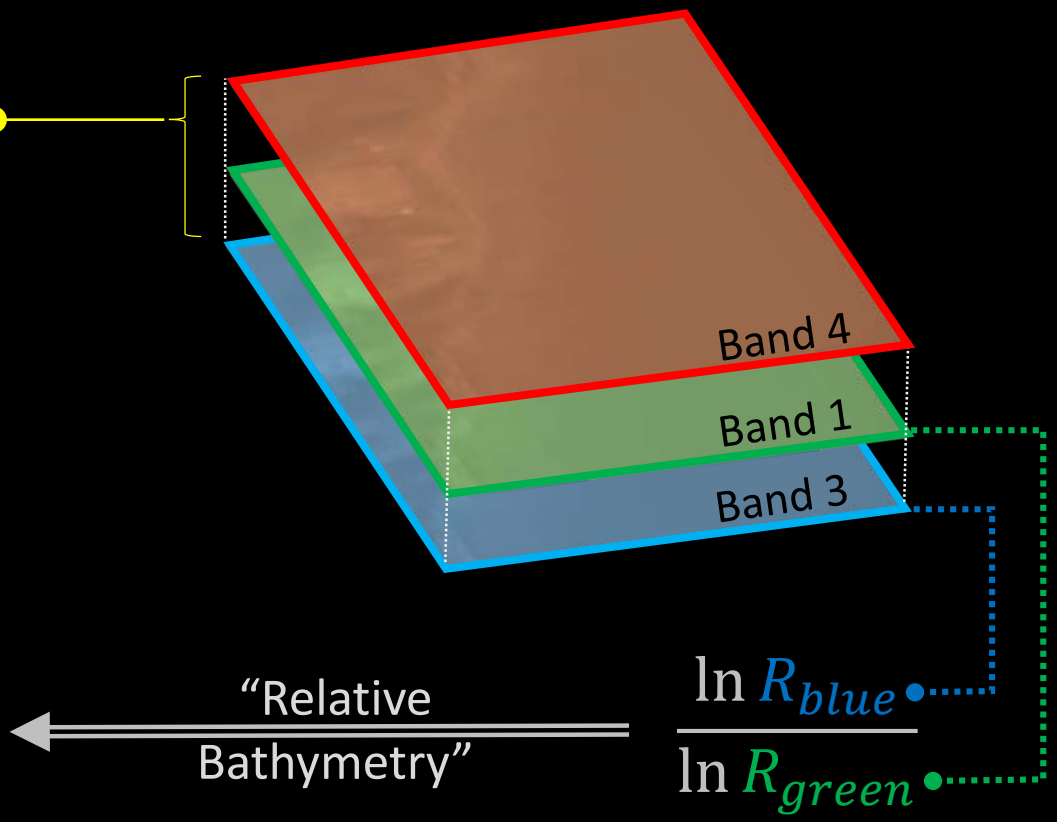
Integrate with Image-Derived Bathy



Aerial/Satellite Imagery



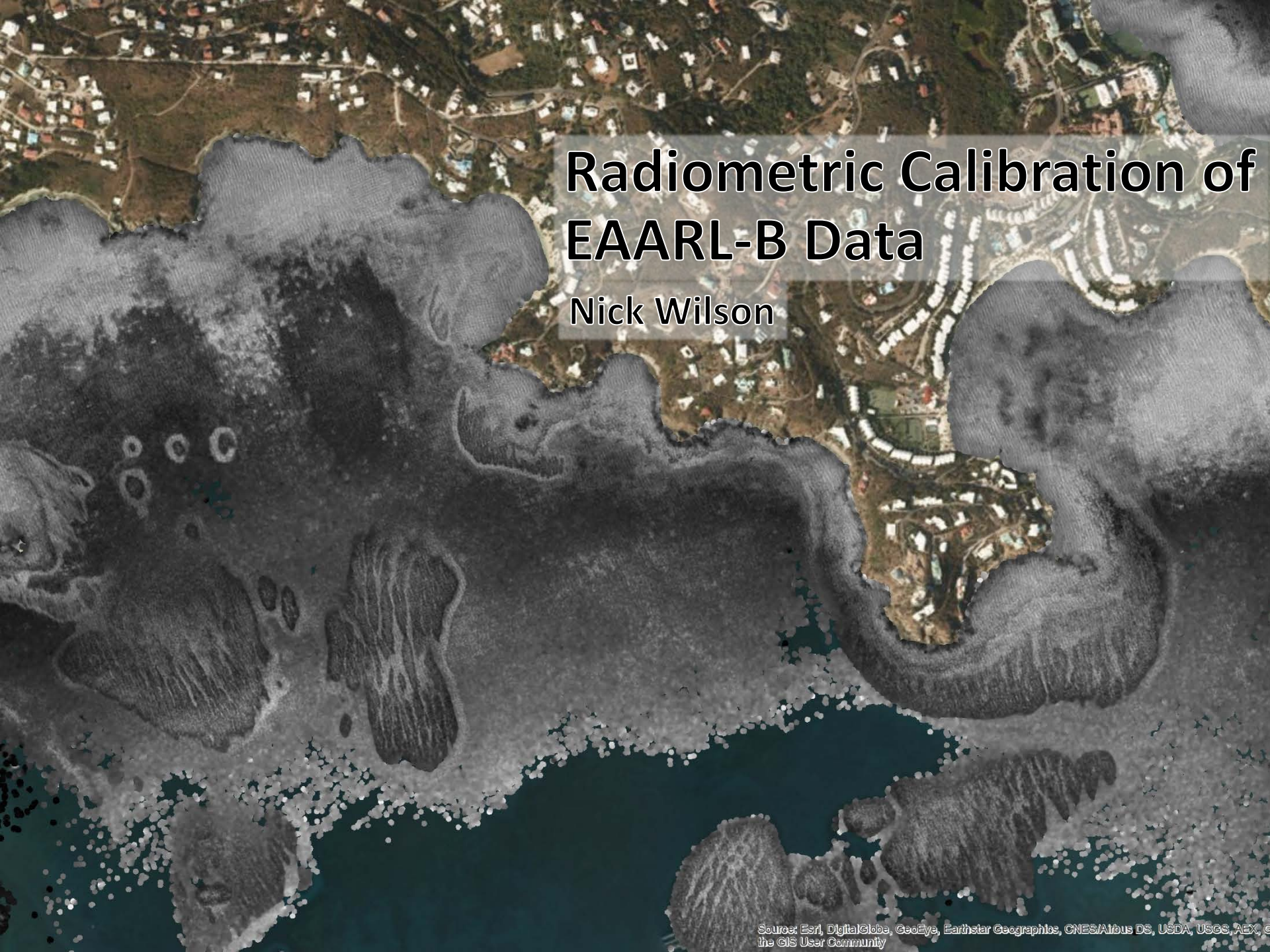
Use MABEL data to transform ratios



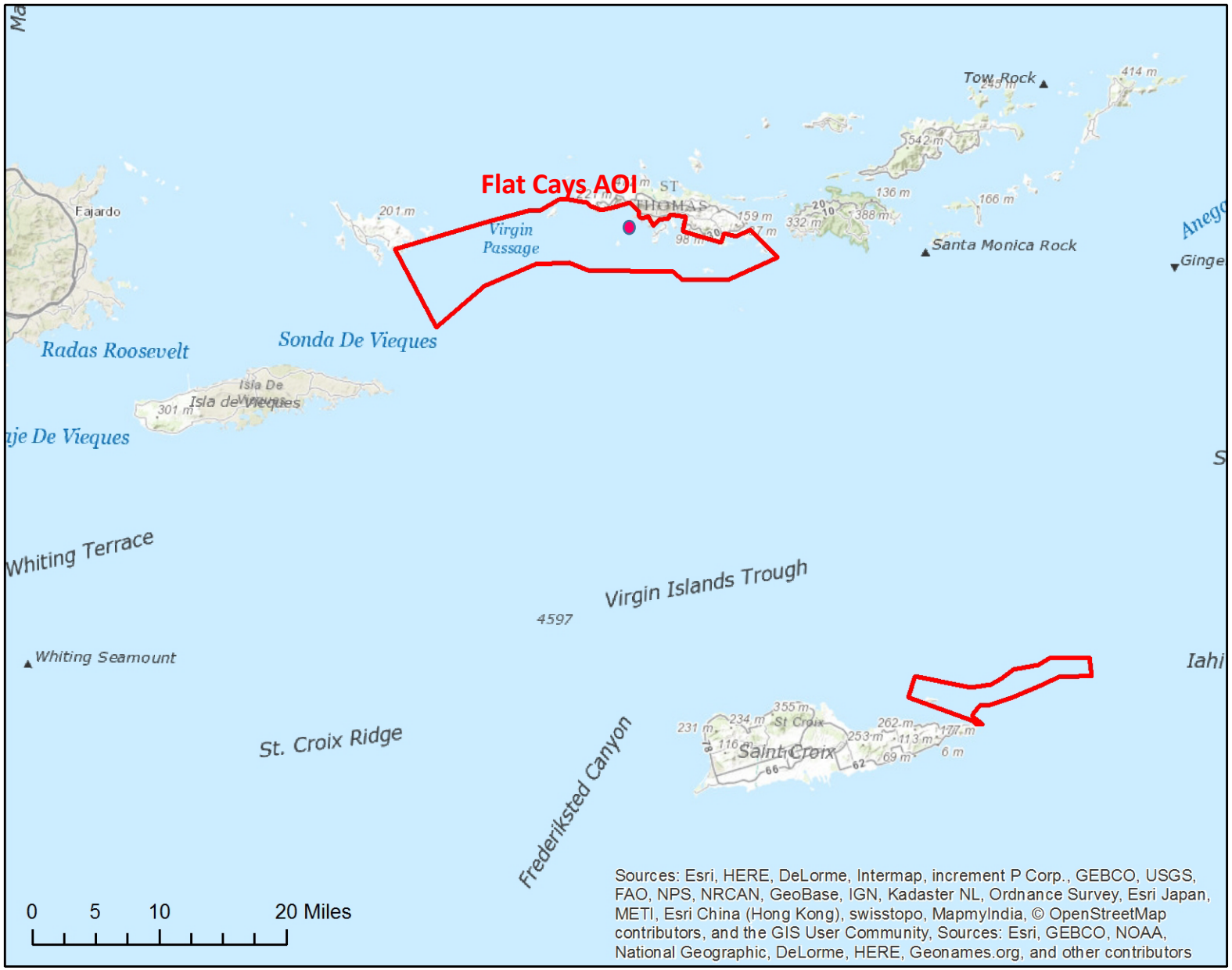
Light differentially absorbs according to wavelength & depth

Radiometric Calibration of EAARL-B Data

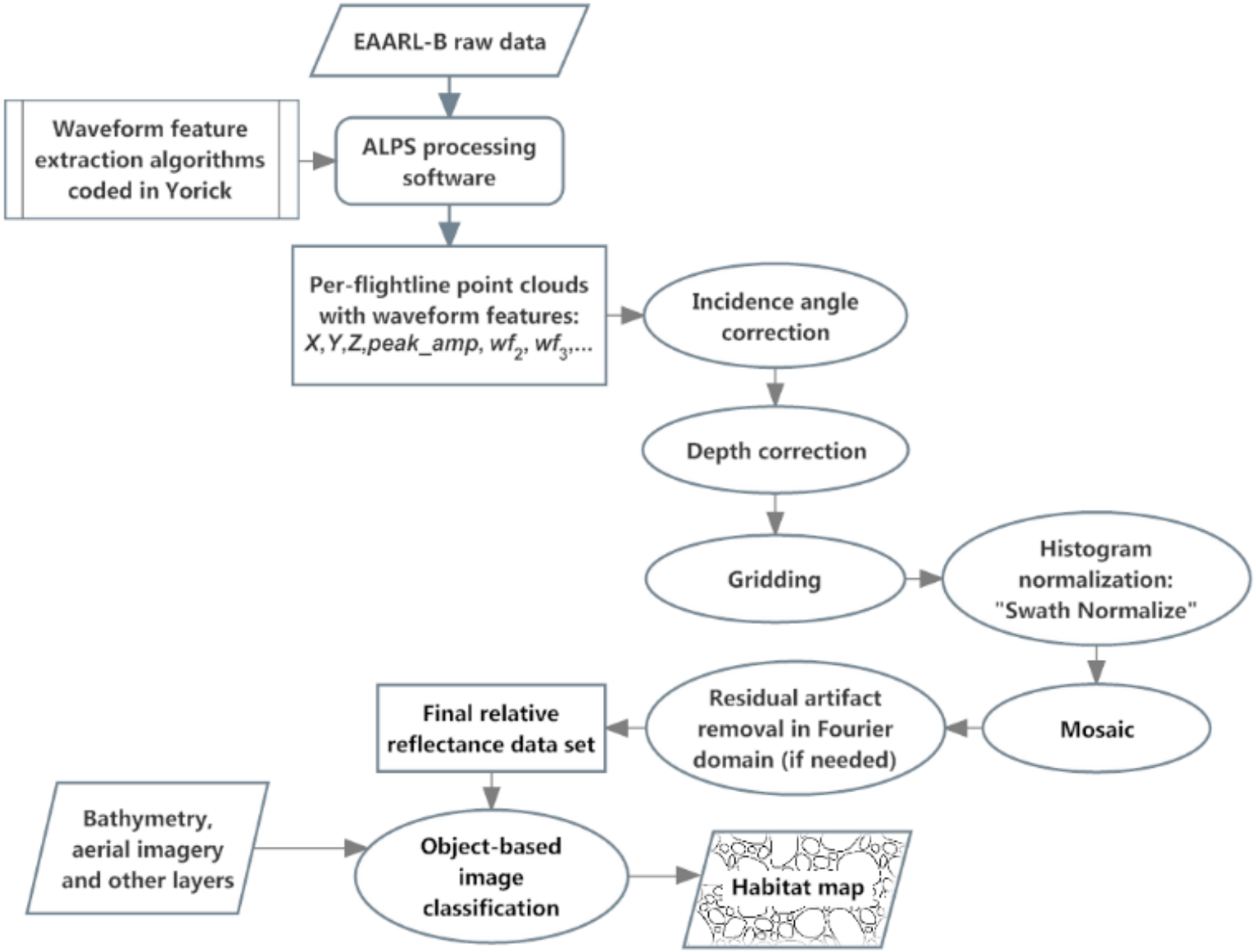
Nick Wilson



Continuation of relative reflectance mapping



EAARL-B relative reflectance mapping workflow



Corrections applied:

- Depth Correction:

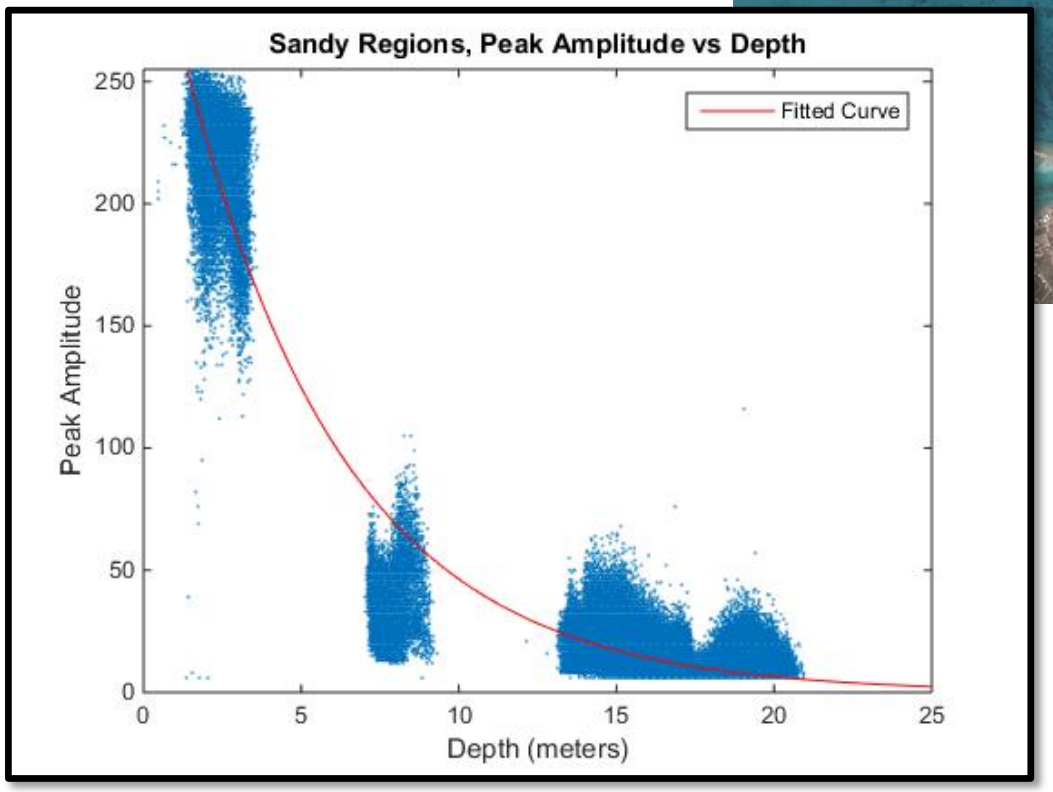
$$I' = \frac{c_1 I}{e^{-2c_2 D}}$$

- Angle of Incidence Correction, based on Phong Reflectance Model:

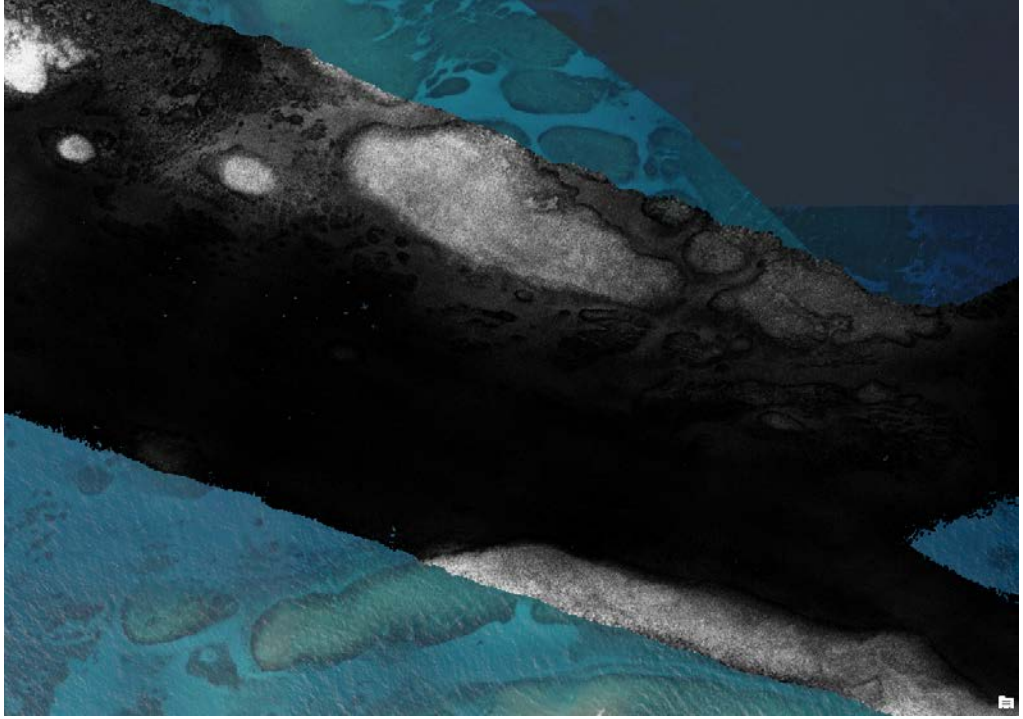
$$I'' = \frac{I'}{(cos\theta)^p}$$

Parameter Derivation

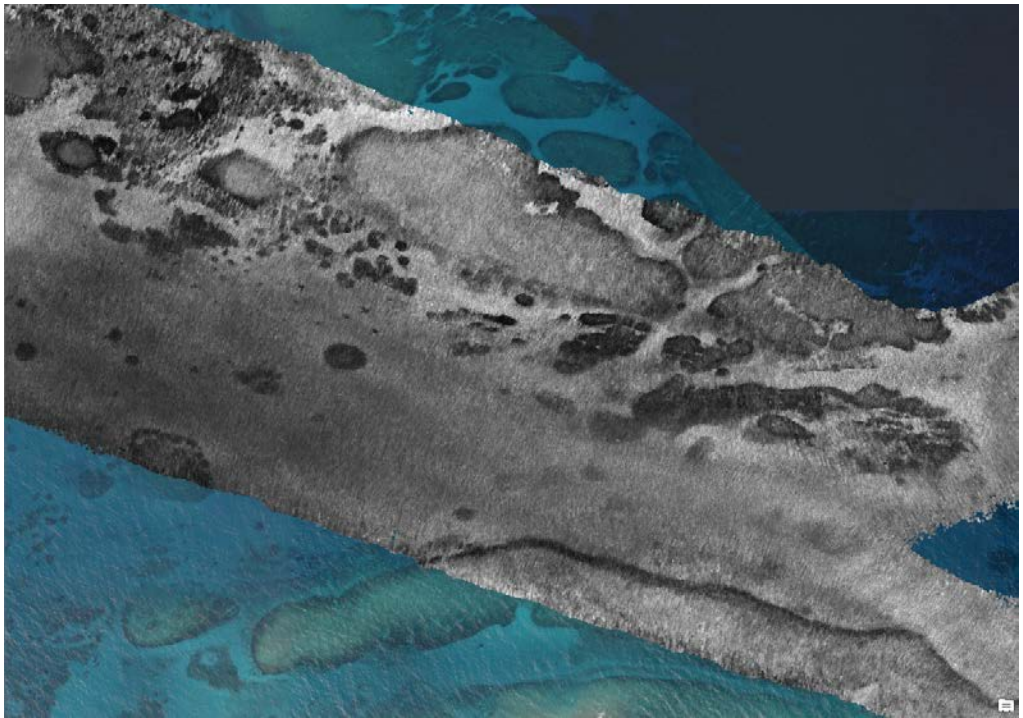
- Areas with assumed uniform bottom type with varying depth

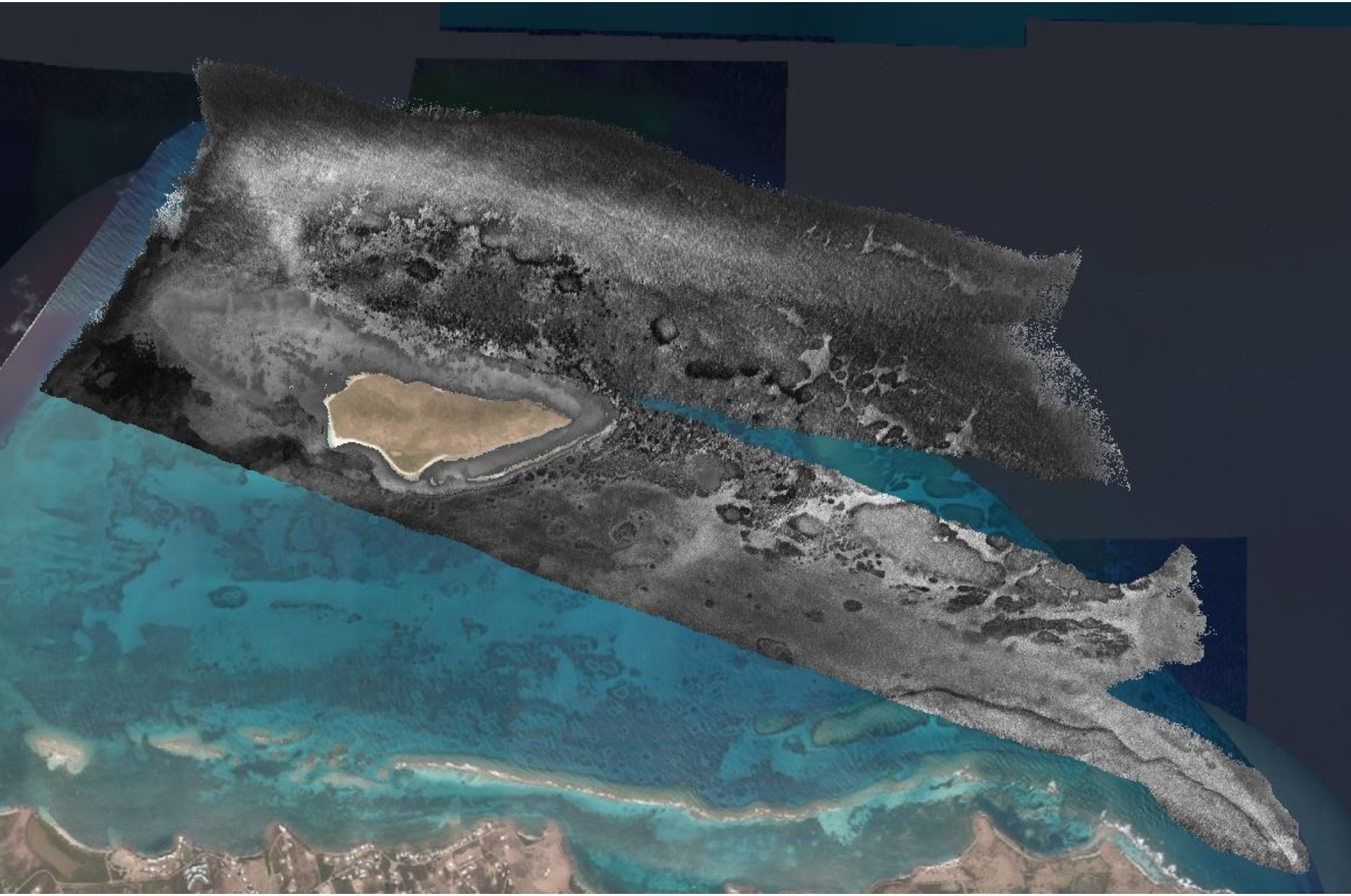


Before: uncorrected, raw intensity

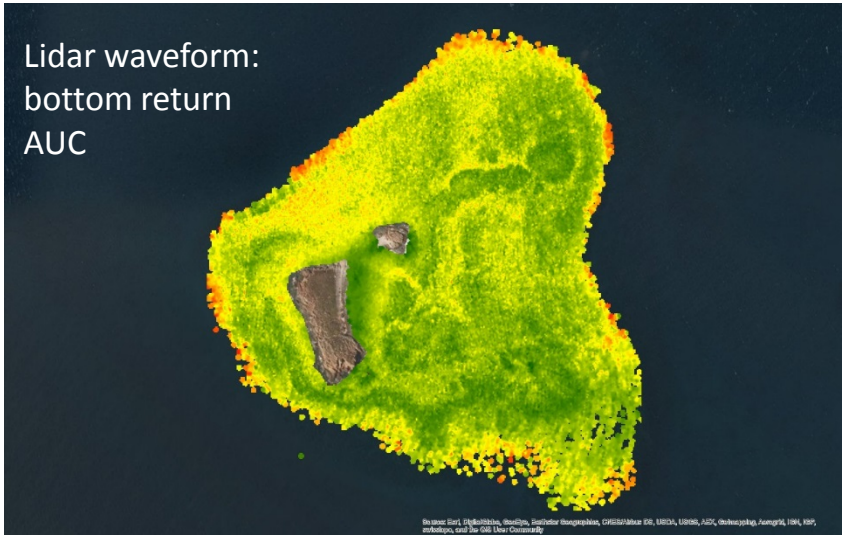


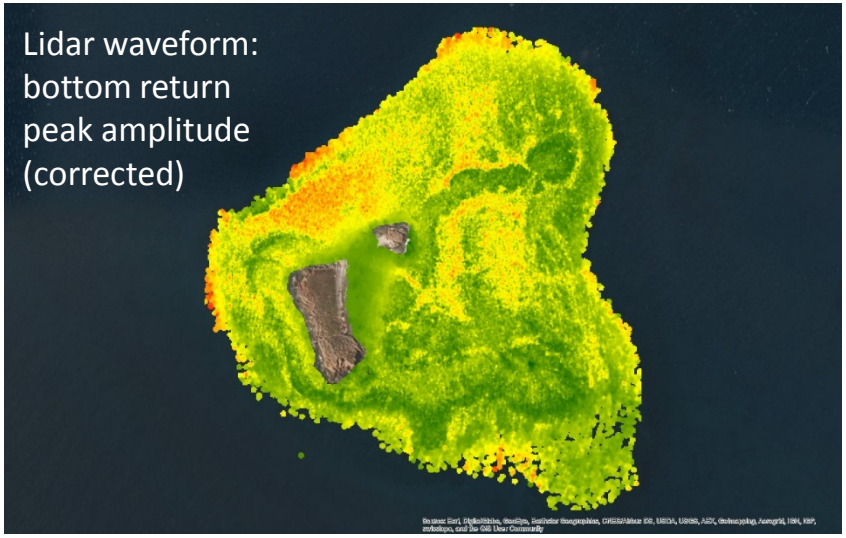
After: seafloor relative reflectance

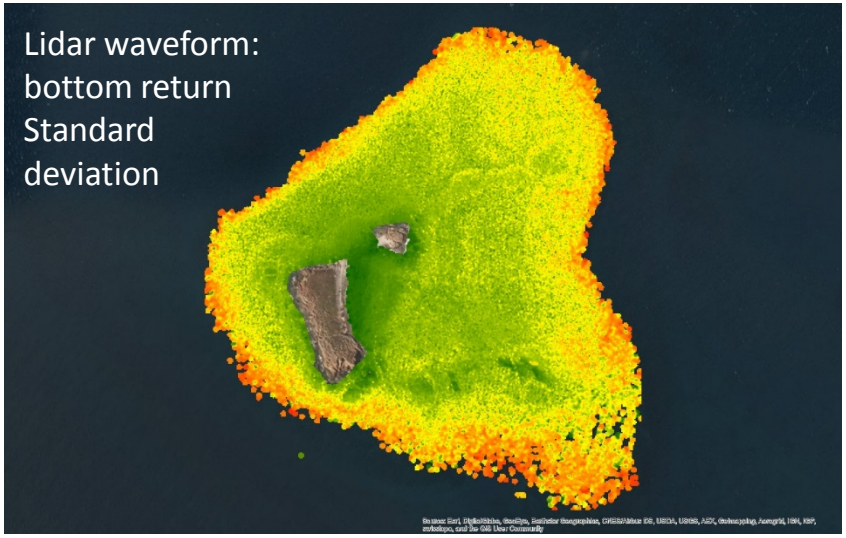




Next phase of this work: additional waveform features for Flat Cays AOI







References

Conner, J. and M.J. Olsen, 2014. Automated quantification of distributed landslide movement using circular tree trunks extracted from terrestrial laser scan data, Computers and Geosciences, 67, 31-39.

Forfinski and Parrish, 2016. ICESat-2 bathymetry: an empirical feasibility assessment using MABEL. Proceedings of SPIE Remote Sensing: Remote Sensing of the Ocean, Sea Ice, Coastal Waters, and Large Water Regions 2016, Edinburgh, Scotland, 26-29, 2016 (to appear).

Forfinski, N. and C.E. Parrish, 2016. Analysis of MABEL Bathymetry in Keweenah Bay and Implications for ICESat-2, *Remote Sensing* (in preparation).

Parrish, C.E., J.A. Dijkstra, J.P.M. O'Neil-Dunne, L. McKenna, and S. Pe'eri, 2016. Post-Sandy Benthic Habitat Mapping Using New Topobathymetric Lidar Technology and Object-Based Image Classification. Journal of Coastal Research (in press).

Acknowledgements

- Funding for this work was provided by:
  - NASA Research Opportunities in Space and Earth Sciences (ROSES): Grant NNX15AQ22G
  - NOAA/NCCOS/CCMA (CIMRS): Grant NA11OAR4320091A
  - USGS / AmericaView, Grant AV13-OR01 (Prime Award: G14A000002)

- Thanks to:
  - Jennifer Wozencraft, USACE, JALBTCX
  - Tom Neumann, NASA
  - Tim Battista, NOAA
  - Bryan Costa, NOAA
  - Craig Glennie, UH, NCALM
  - Jenn Dijkstra, UNH, CCOM-JHC
  - David Nagle, USGS

Questions and Additional Information

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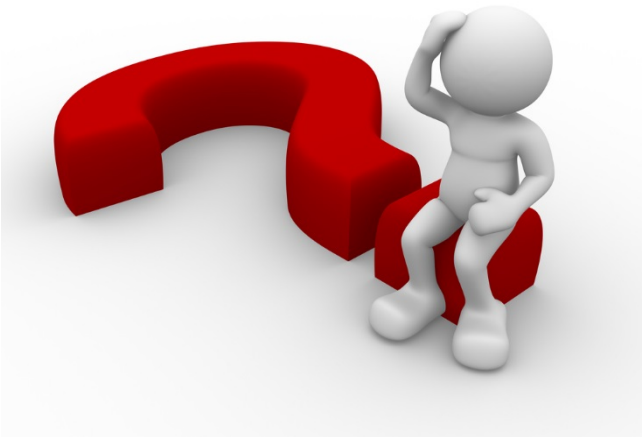

Additional MABEL specs

Parameter	Value
# green channels	16
# NIR channels	8
Transmit pulse length	2 ns
Pulse repetition rate	10 kHz