Questions & Answers Part 2

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Sean McCartney (sean.mccartney@nasa.gov).

Question 1: When integrating ATL24 datasets from ICESat-2 for shallow-water bathymetry, do you typically use machine learning approaches? If yes, which techniques are most frequently applied (e.g., Random Forest, CNN, XGBoost), and why are they preferred over traditional methods?
Answer 1: ATL24 provides bathymetry from ICESat-2. The primary inputs are ATL03 geolocated photon returns from nearshore coastal areas. For integrating ATL24 with spectral imagery to generate gridded bathymetric products, there are a number of M/L algorithms that can be used. A recent ICESat-2 bathymetry review paper by Jung et al. contains a lot of references.

Question 2: Could you suggest some case studies where ICESat-2 ATL24 imagery has been applied for ecosystem monitoring or restoration projects? For example, coral reef mapping, seagrass monitoring, or coastal habitat restoration.
Answer 2: There was a publication referencing ICESat2 Bathymetry benthic mapping and we will include the reference in the final transcript.

Question 3: If we are integrating ICESat-2 ATL24 datasets with multispectral remote sensing data, such as Sentinel-2 imagery, what are the best practices to improve accuracy? Which remote sensing datasets are most frequently used for this purpose, and why? Are there any tips for preprocessing, filtering, or modeling that can enhance bathymetry estimates?
Answer 3: Methods of improving accuracy: careful selection of input scenes (e.g., avoiding clouds, turbidity, artifacts), compositing of several scenes of imagery, robust atmospheric correction, careful selection (and, if needed, refinement) of ATL24 calibration data. It is also recommended to perform accuracy testing using independent reference data, where available.

Question 4: Will this work for the purpose of archaeological diving?
Answer 4: Marine archeology is an interesting application of ICESat 2 bathymetry and ATL24.

Question 5: Are ICESat-2 ATL24 datasets used for applications like natural resource exploration or disaster monitoring, such as tracking sediment deposition? And can they be applied in hydrocarbon exploration as well?
Answer 5: In relation to disaster monitoring, there is a publication referencing ICESat 2 for hurricane monitoring and it is relevant.

Question 6: How does the vertical accuracy of ATL24 compare to standard single-beam hydrographic surveys in clear water? Can I use ATL24 to validate or even correct my existing field data?
Answer 6: Generally, ICESat-2 bathymetry is not as accurate as single beam (or multibeam) data. We did a study of ATL24 accuracy which was published in the following paper. The RMSEs for the 8 test sites were: 0.68 m using all points and 0.43 m using just high-confidence points. Parrish, C.E., Magruder, L.A., Perry, J., Holwill, M., Swinski, J.P. and Kief, K., 2025. Analysis and accuracy assessment of a new global nearshore ICESat-2 bathymetric data product. Earth and Space Science, 12(8), p.e2025EA004391.

Question 7: Did you use Sentinel-2 data instead of Landsat for the spatial resolution for the model? Does this improve the model?
Answer 7: It is certainly possible to use Landsat 8 or 9, rather than (or in addition to) Sentinel-2 in combination with ATL24 for generating SDB. We have also used both.

Question 8: My area of interest is a coral reef with high morphological complexity (rough slopes, sudden drop-offs, and narrow valleys). Since the ICESat-2 laser footprint is roughly 11–17 meters, does it effectively capture these sharp changes, or does it 'smooth out' the bathymetry too much for precise coastal mapping?
Answer 8: Great question. Yes, ICESat-2 ATLAS's footprint is ~11 m, which can be a limiting factor in detecting high frequency spatial detail. Importantly, however, the along track point spacing (along a particular beam track) is quite good (~70 cm), which can help in resolving features. I would use the SlideRule web client (https://slideruleearth.io/) to investigate ATL24 in your area of interest to investigate the data and see if it will meet your needs.

Question 9: When you do the change analysis with Sentinel-2, do you calibrate the reflectance with ATL again or use the regression coefficient from the original calculation and apply it to all the Sentinel imagery?

Answer 9: My recommendation would be to calibrate the imagery from each epoch separately. However, you could start with the calibration parameters from the first epoch and refine them, as needed.

Question 10: Data Collection model for Water Turbidity based on size, weight. composition. settling rate; overlay with world currents and closest coastal impacts? Does it need to include baseline Turbidity Levels? Possible to make moving animated data overlay: over seasonal tidal and trade wind change prediction models for cumulative impacts.
Answer 10: To the best of my knowledge, this doesn't currently exist, but I agree: it would be an extremely useful tool!

Question 11: How can tide be applied or removed from pseudo SDB?
Answer 11: Regarding tide correction, if you're doing single scene SDB (not compositing multiple scenes), and your calibration data (e.g., ICESat-2 bathymetry, airborne bathymetric lidar or MBES) are already referenced to a vertical datum (which could be a tidal datum), your output SDB will be inherently referenced to the same datum, with no explicit tide correction step needed. For example, consider that the conversion from pseudo SDB to SDB uses a linear transformation. The offset term can inherently account for a vertical shift.

Question 12: Since the interest is in bathymetry, would we want to sample satellite data just after ice off to avoid phytoplankton that might be growing in the water column in the later spring and summer, which could mask the bathymetry?
Answer 12: Yes. I would monitor global turbidity to find optimal times to find good bathymetry.

Question 13: Does the Stumpf approach only work with the ratio of ln(R.blue)/ln(R.green) or could other band ratios be applied?
Answer 13: You can do other band ratios, as mentioned in Gretchen Imahori's presentation. This is also good for hyperspectral imagery.

Question 14: Have you tried to compare your depth data (or the data source being discussed) against real-world bathymetry data products, such as the NOAA BlueTopo, to assess its accuracy?
Answer 14: The accuracy assessment included in the chat included some of the information in BlueTopo.

Question 15: What quality criteria in ATL24 would you specify to filter out noisy data? Since I will be working with an inland waterbody, can you specify comparable quality criteria for ATL13 data?
Answer 15: For ATL24, we recommend a confidence threshold that provides a confidence of bathymetry classification. ATL13 is the corresponding product for inland water bodies. There is not a similar confidence threshold.

Question 16: How would you integrate the SDB layer with the point bathymetry data?
Answer 16: If it is referenced with integrating pseudo Bathymetry with ATL24, it is mentioned in the first demo of this training.

Question 17: What about the difference in pseudo SDB per S2 detector (12 dects)?
Answer 17: We will look into this further.

Question 18: I've collected hydrographic survey data across my study area. How should I combine field-based hydrographic data with ICESat-2 along-track measurements to create a more robust validation dataset? What are the trade-offs between them?
Answer 18: You will need to consider the differing spatial resolutions and accuracies, and to transform (if necessary) to a common reference frame and consistent vertical datum. NOAA's VDatum utility can be very useful for this: https://vdatum.noaa.gov/.

Question 19: Where can I access the SatBathy tool?
Answer 19: Currently the NOAA SatBathy tool is for NOAA internal use only BUT we are working on a public larger cloud effort. This will incorporate lessons we have learned over the years as we work with NOAA's Office of Coast Survey and our other federal mapping partners. Please feel free to contact me: Gretchen.Imahori@noaa.gov if you want an update on our status.

Question 20: The example in Alaska was fascinating. Have there been any studies looking at the efficacy of these approaches in polar regions in particular, given the challenges presented by snow and ice?
Answer 20: We have been trying to do research in parallel (where possible) with our SatBathy SDB for reconnaissance operational work for NOAA's Office of Coast Survey. Alaska alone is a very challenging area so there is more research needed as we continue to work here and in other northern areas.

Question 21: I missed the definition of sdb_merged and sdb_red. Could you explain?

Answer 21: sdb_red is better for shallower waters and sdb_green is better for deeper waters. Sdb_merged is the combination of those two algorithms. More information can be found in the following publication https://www.mdpi.com/2072-4292/12/3/451

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Question 1: Can ATL24 bathymetry points be interpolated into a continuous 2D digital terrain model Digital Terrain Model (DTM)?
Answer 1: In areas where there are a lot of available ICESat-2 tracks (within a specified time window) containing bathymetry, yes, it is sometimes possible to interpolate the data to create a gridded surface. More typically, if a gridded product (bathymetric DEM) is required, it is necessary to combine ATL24 with spectral SDB, as in the demos in this session.

Question 2: I noticed that in the raw ATL24 there are some outliers. Is there a process to remove these outliers in ATL24 data before the calibration? And why is the linear relationship picked?
Answer 2: Some of those incorrect Class 40 (bathymetry) points will be removed in Version 1 Release 2 of ATL24, which should be available in SlideRule in the next week and at NSIDC in the next few weeks. If you need to filter the data, there are a number of software tools that enable displaying a profile and using a lasso tool to reassign points from Class 40 to the noise class. Regarding the linear transformation, it isn't necessary to assume a linear relationship: you can use a quadratic or higher-order polynomial but with the possible risk of overfitting

Question 3: You will get different pseudo bathy for different images on different days. Also, ideally you would want dates for ATL24 to match the imagery dates...but that would reduce the amount of ATL24 data. Do you have a feel for how sensitive the process is to timing (assuming constant bathy)?
Answer 3: It depends on the area. When the bathymetry is rapidly changing, you need to reduce the time between image acquisition and validation/calibration through ATL24.

Question 4: I know Copernicus HUB Sentinel-2 L2A data applies land base atmospheric correction. What about "water leaving correction" covering Rayleigh Scattering, sun glint, dark surface effects to satellite imagery (by using ACOLITE or C2RCC or other methods), will that increase accuracy?

Answer 4: Great point! Yes, you can improve accuracy using atmospheric correction optimized for coastal waters. Gretchen will discuss the use of ACOLITE in a demo later in this session.

Question 5: A question regarding the "monitoring dynamic bathymetry" concept mentioned by Prof. Parrish during the demo. I'm assuming this refers to sedimentation processes? Sentinel-2 provides frequent updates, but ATL24 does not. Given the sparsity of usable ATL24 data within a specific region and time window needed to build the regression model, I'm wondering how the dynamic tracking is intended to work.
Answer 5: Ideally, some of the ATL24 bathymetry will be in an area of relatively little change over time, so you can use the data from that area for calibration of multiple epochs of Sentinel-2 imagery.

Question 6: This is quite nice, but I guess high water transparency is needed. I have tried in tropical Pacific waters and the result is quite bad (very few valid bathymetry photons).
Answer 6: Yes, water clarity is the primary limiting factor, not only for ICESat-2 bathymetry, but also airborne bathymetric lidar and spectral SDB. Fortunately, ICESat-2's revisit cycle provides many opportunities for acquisition at a time of good water clarity, since water clarity is highly temporally variable in many areas.

Question 7: Where do we get the SatBathy Tool?
Answer 7: The SatBathy tool is currently internal to NOAA, but there is work being done on a public facing version of SatBathy.

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