Questions & Answers Part 1

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: Can we develop watershed models using the data from the ICESat-2 imagery? What would be the minimum resolution?
Answer 1: Hopefully the presentation helped explain the format of ICESat-2 data. As opposed to imagery, we are looking at photon return footprints of 6 beams (3 beam pairs). Each beam pair is 3km apart with 90m between the strong and weak beams in a pair. The along-track resolution is ~70cm. This being said, the data is excellent for validating portions of watershed models. The elevation data is very good for validation.

Question 2: Can we derive data for different time periods to do comparisons? It would be useful for seabed mobility assessments.
Answer 2: Yes, the ATL24 product is derived from the ATL03 photons that have been collected since the start of the mission in 2018. Temporal subsetting is available for the granules. The satellite has a 91 day return period, but pointing variations can affect data locations.

Question 3: Is the ATL24 product already corrected for tides, or is this a post-processing step we have to consider specially for locations where tidal range is considerably wide?
Answer 3: Due to the range of resolutions and accuracy of available tide models, ATL24 does not correct for tides. This task is left for the user. The ATL24 datafiles contain both ellipsoidal heights and orthometric heights providing a flexible approach to users for various datum corrections.

Question 4: That's a very clear scatterplot. Could you tell me about the steps taken to check for overfitting? (Question for Lori – Slide on "Accuracy Test Results")
Answer 4: It's true that the ensemble model we use is prone to overfitting. We control overfitting by adjusting the model's hyper-parameters and, more effectively, we apply a 'blunder detection' after classification in order to correct for obvious errors (e.g., bathymetry detected when no sea surface was detected). Individual algorithms may or may not overfit depending on their nature.

Question 5: How much work will it take to extend this approach to inland waters? Is it possible, and is any team working on such a product? What about in Northern latitude lakes and ponds?
Answer 5: There is already an inland lake data product (ATL13). The current processing mask is just coastal waters. In the future, there will be an 'on-demand' service that will allow users to apply the ATL24 algorithms to any arbitrary AOI. This will be made available through Sliderule.

Question 6: What applicability does this data have for bathymetry mapping of inland and near-coastal lakes?
Answer 6: If a lake is within our coastal mask, it will be processed the same as coastal waters. Inland lake data product (ATL13). Sliderule allows for access.

Question 7: Are positive depth biases in ATL24 common, and what could be the cause?
Answer 7: This is a tricky question to answer because it requires coincident reference data. Temporally coincident datasets are not common, but we are working on large-scale analysis with respect to the NOAA BlueTopo dataset to get a better idea of how prevalent this is. We would like to hear from users on biases you may be seeing. Forward scattering bias

Question 8: Does the SlideRule Web Client apply any de-noising or classification algorithms before presenting ATL24 bathymetry points, or are we viewing the raw ATL24 photon returns?
Answer 8: Accessing through the webclient it is the raw data. There are other APIs that have additional

Question 9: How does ICESat-2 distinguish between photon returns from the sea surface and photon returns from the seafloor in shallow coastal waters, especially considering issues like photon noise and surface wave variability?
Answer 9: We train our models on a lot of different groundtracks that exhibit a range of sea surface states and bathymetric geomorphologies. Generally, the ensemble is able to distinguish between sea surface and shallow bathymetry across a range of noise levels. However, excessive noise and extremely large (> 3-4 m) waves can hinder this. It is important to note that in rough sea states, bathymetry retrieval is generally not possible due to the refraction and scattering at the surface. In terms of vertical resolution, there is a difference between strong/weak beams and day/night acquisitions. In the second release (V2) we addressed this.

Question 10: How does ATL24 handle the challenge of separating true seafloor returns from water column backscatter in shallow coastal zones where turbidity is high?
Answer 10: Some algorithms make assumptions about the signal (e.g., sea surface always has more returns than the sea floor). Other algorithms, like Coasnet, do not make these same assumptions and are capable of separating the two signals because they operate on high vertical resolution profile imagery. Also, an advantage of using the ensemble is that it has the capability to choose the correct output in ambiguous environments. Of course, there is a limit to this. At some point the turbidity and background noise will overwhelm the signal to the point where it cannot be retrieved.

Question 11: Is bathymetry available for large river systems, like the Mississippi River, or are there too many issues with turbidity or orbital paths/shoreline geometry?
Answer 11: Bathymetry is only available inside the coastal mask. This only covers estuarine environments. As long as there are data in the mask, it will be processed. If the water turbidity is high, bathymetry extraction is unlikely. However, a number of factors influence the bathymetric signal detection including strong/weak beam and day/night acquisition. ATL13

Question 12: In Sliderule, is the data derived per line only, so the spatial variability is poor?
Answer 12: All the data products are along track. We hope to provide

Question 13: Does the Python library allow for larger bounding boxes?
Answer 13: The limitation for harmony-py is on the data supply end, but yes you can set your bounding box. Your code may stall a bit. For reference: https://harmony.earthdata.nasa.gov/. Sliderule lets you do this, but it is a very large amount of data.

Question 14: Is turbidity the main thing affecting the confidence level? Does that come from VIIRS?
Answer 14: Not necessarily. Turbidity will have a significant impact on the signal to noise in the water column. It causes more photons to be scattered making it harder to clearly identify bathymetric surfaces. However, the state of the sea surface (large vs. small waves) can impact the amount of photons that make it through the water surface. The confidence value comes from the ensemble XGBoost model and is influenced by

the number of algorithms that classify a photon as bathymetry. A simple analogy is that if a photon is classified by all constituent models as bathymetry, then it will have a higher confidence. There are additional factors that influence the confidence including the predicted depth, and standard deviation of the sea surface.

Question 15: Can we use it for detecting plate movement of tidal areas to get information about upcoming earthquakes?
Answer 15: This is not something that we have explicitly looked at. Spatial resolution and accuracy may not support this application, but if a user can provide insight into this we would

Question 16: Are you able to use the ICESat-2 data to extract inland bathymetry?
Answer 16: This can be found in the ATL13 inland water product.

Question 17: In Satellite-Derived Bathymetry (SDB) workflows that use ATL24 as reference data for training models on Sentinel-2 imagery, are turbidity and bottom-type limitations generally encountered first in the multispectral reflectance, rather than in the ATL24 lidar signal?
Answer 17: In Part 2 we will talk about ATL24 combined with multispectral imagery. Turbidity is the limiting factor.

Question 18: Are there tools available for accessing the ATL13 products such as Sliderule?
Answer 18: Yes, please see the dataset landing page: https://nsidc.org/data/atl13/versions/7.

Question 19: Is there a gridded product available (or planned for the future) for the US East/West Coasts?
Answer 19: The team is not addressing this, but combined overpasses may provide data to derive a gridded product.

Question 20: What changes are expected to the Confidence Levels next year?
Answer 20: We are actively improving the constituent models and investigating new models to add into the mix. The confidence levels are entirely dependent on capabilities of the constituent models. After building the ensemble and prior to publishing the next version of ATL24, we will conduct a study of confidence values relative to reference bathymetry datasets to determine the updated ‘best practice’ value to use.

Question 21: How critical is VIIRS Kd490 to the uncertainty assessment? I would think clouds and land adjacency would greatly reduce the quantity of Kd490 retrievals, and quality of these retrievals will be reduced in optically shallow waters (unless alterations to the 'standard' Kd490 algorithm are used to minimize benthic contamination).
Answer 21: The VIIRS Kd490 data is used only as a rough guide to influence the expected areas of bathymetry extraction. In the uncertainty look up table, they are used to search for appropriate uncertainty values to assign to a photon. All this is to say that the Kd490 VIIRs data does not directly impact the classification of photons, but it does impact the uncertainty in their position.

Question 22: Why not use Kd490 in a green band (e.g., VIIRS 555nm)?
Answer 22: The global Kd are generally provided. It would be better to use 532.

Question 23: Can I get access to the data for Nigeria?
Answer 23: This is a global dataset so lower latitudes are included.

Question 24: Could this be used to map objects near coasts like vessels, buoys, jetty's, etc.?
Answer 24: If the RGT goes over an object, it could be possible to resolve them, depending on the clarity of the water, etc. It is a function of the resolution (~70 cm). If a trackline captures it, it will show.

Question 25: What happens in the presence of algae blooms or seagrass?
Answer 25: These would reduce/block the photons that would be able to pass through and detect the sea floor. Seagrass has relatively low reflectance. How that affects the accuracy is unknown.

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Question 1: Are there plans to extend future versions of ATL24 to include the Great Lakes or other lakes?
Answer 1: The ATL24 granules are only produced inside the coastal mask. There is an existing inland lake bathymetry product (ATL13). https://nsidc.org/data/atl13/versions/7

Question 2: Is there a plan to extend the coverage for river bathymetry in the future?
Answer 2: Rivers and lakes are covered in a separate ICESat-2 ATLAS data product for inland waters, ATL13. https://nsidc.org/data/atl13/versions/7

Question 3: What are the key environmental factors (e.g., water clarity/turbidity, sea surface roughness, seafloor reflectance) that limit the depth and accuracy of ATL24 measurements?
Answer 3: All of the above, but the water turbidity and sea surface roughness play a much larger role in bathymetry extraction. There are additional factors that impact extraction including the strong/weak beam and whether the ICESat-2 satellite acquired data during the day vs at night. At night, there are fewer noise photons and improved chances of bathymetry extraction.

Question 4: I am trying to find the most efficient tool to obtain recent satellite/airborne lidar data of the bottom of the ocean to assess the coverage of algae. What tool would you suggest I use noting that bathymetry would be relevant to assess the volume of algae in 3 dimensions (height of the algae)?
Answer 4: This is a challenging problem. You would need multiple scans of the bathymetry where there is algae in one collect and another where algae is not present. Without two collects, it will be difficult to know whether the bathymetry extracted is truly bathymetry or actually scattering from algae. In all likelihood, in the presence of algae, there will not be any signal. Instead there will be a 'denser' water column.

Question 5: Are these datasets available on Google Earth Engine?

Answer 5: No, data are not available in GEE to my knowledge. Data access methods can be found in the Data Access and Tools section on the data set landing page: https://nsidc.org/data/atl24/versions/1. NASA and NSIDC DAAC provide a variety of data access methods from graphical user interfaces to programmatic access methods via API's. The number of access options can feel overwhelming. You are welcome to email nsidc@nsidc.org for advice on the best fit method for your needs.

Question 6: Do the ATL24/ATL13 products overlap over estuaries/deltas, or do they have a clear mask boundary?
Answer 6: There will be overlapping in estuaries/deltas of both ATL13 and ATL24.

Question 7: Are there any plans to increase resolution for coverage of small island states?
Answer 7: The ICESat-2 mission provides global coverage but a very narrow ~11m beam footprint. There are gaps in data coverage due to the nature of photon counting LIDAR altimeters and orbit requirements, but the 'resolution' of ATL24 is at the individual photon level.

Question 8: Will version 2 address the problem of mislabeled photons?
Answer 8: Yes, we are making many improvements to the classification and estimation algorithms in version 2. For example, we are developing a regression model that constrains the solution so that you can't get nonsensical results (e.g. bathymetry photons above the sea surface). These constraints will greatly improve the quality of the classifications by reducing false positives. It will also make it easier to derive elevation estimates for the various signals (surface, bathymetry, ground, …, etc.). We are also adding new algorithms to the ensemble that should help reduce the errors in classification. Finally, we will add more features that can help the models/algorithms distinguish between different contexts (e.g. melt ponds and mangroves only exist at specific latitudes).

Question 9: What is the average vertical accuracy (in meters) of ATL24? Is it depth dependent?
Answer 9: At the core of ATL24 is photon classification. The ensemble classifies photons as sea surface or bathymetry. Depending on the quality of the raw data, (i.e. signal to noise ratio) the accuracy depends on the 'cloud' of classified photons. In general the signal fades at deeper depths, but that does not necessarily mean reduced accuracy in metric units. The vertical accuracy of ICESat-2 measurements is better than 10cm in terrestrial environments. In bathymetric environments we are limited in

available temporally coincident reference data making large scale assessments challenging.

Question 10: How can we use the data for sedimentation?
Answer 10: We are not sure what exactly is meant by sedimentation. If you are referring to turbidity, you would have to have a way to normalize it against noise in the water column. It is easier to separate turbidity in the water column.

Question 11: What is the accuracy of ICESAT-2 data both horizontal and vertical?
Answer 11: Horizontal accuracy is ~5 - 10 meters. Vertical accuracy is more like ~1 - 2 cm. Of course, those two are related to one another in that horizontal errors can affect vertical accuracy (and vice versa).

Question 12: Any thoughts on the unknown classified photons? Could it be large schools of fish or debris?
Answer 12: They can be these or something else. We know that ATLAS sometimes produces afterpulsing artifacts that look like vertical shelfs but are in fact just artifacts. The ML algorithms that use labels will include a new label that will help us distinguish different types of unknowns.

Question 13: Can the rate of cliff retreat be detected?
Answer 13: With the assumption of these being coastal cliffs, then yes. There are papers that have been published covering this topic.

Question 14: I am a navigator working with a seismic data company on a transition zone. We've experienced loss of material from different tanker vessels working in our workspace. Can this bathymetric data help in any way for tracking these materials? The material I am talking about are passive Manta Nodes with no GPS tracking. Can this bathymetric data be of any help?
Answer 14: This data most likely can be used with imagery data for wide spatial coverage in conjunction with bathymetry data for analysis.

Question 15: Is there a map summarizing ATL24 bathy data globally? I found it was very sparse in areas I looked at.
Answer 15: You could use Earthdata search for a wide view of the data available and over your area of interest: https://search.earthdata.nasa.gov/search/granules?p=C3433822507-NSIDC_CPRD&pg%5B0%5D%5Bv%5D=f&pg%5B0%5D%5Bgsk%5D=-start_date. This process does

take a bit of work for the end user - scrolling through the file list will highlight their location on the map view. For close-in looks, SlideRule is a great tool as well to see where the actual measurements fall within your area of interest. We can also suggest looking at the water mask for ATL24 that was shown in Lori Magruder's section of the presentation as a starting point. However, actual bathymetry data could still be sparse in areas. The map of the water mask is contained in her 2025 et al. paper: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2025EA004390