Questions & Answers Session 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 Amita Mehta (amita.v.mehta@nasa.gov) or Sean McCartney (sean.mccartney@nasa.gov).

Question 1: Is it possible to measure the altimetery of lakes using Landsat data?
Answer 1: No, it is not possible to measure the altimetry of lakes using Landsat data. The Landsat missions do not possess an altimeter like those described in today's presentation. Landsat imagery does provide for the surface extent of lakes and reservoirs, and when used with altimetry and bathymetry data can be used to calculate water volume.

Question 2: Is Sentinel-1 not considered in the Missions preview slide for any specific reason?
Answer 2: Sentinel-1 was not considered in the Missions slide because it does not provide altimetric data. Sentinel-3 does. Sentinel-1 can be used for extent mapping.

Question 3: In your presentation you said that: "Getting radar altimeter echo over lakes and reservoirs is a complex thing". Would you please elaborate a bit on the sources of complexity?
Answer 3: To derive lake level height from radar echoes requires several processing steps. The technique is validated--see the tutorial and Birkett paper for methodology.

Birkett C. and B. Beckley, 2010: Investigating the Performance of the Jason-2/OSTM Radar Altimeter over Lakes and Reservoirs, Marine Geodesy, 33:S1, 204-238, DOI:10.1080/01490419.2010.488983.
Also, http://www.altimetry.info/radaraltimetry-tutorial/training-material/ provides tutorials and training material.

Question 4: Is the Jason-3 data available for India and is it free?
Answer 4: Yes, Jason-1,2,3 sea surface height is freely available for the Indian Ocean.

Question 5: How is average height derived per pixel in altimetry? If the radar measures the echoes, how can you tell the distance per pulse with backscatter?
Answer 5: Time taken to receive radar backscatter depends on the lake surface height - so that is converted to height. A fixed earth ellipsoid is used as a reference height.

Over a lake when multiple repeat observations are available, heights derived from them are averaged for the lake.

Question 6: Is it reasonable to assume that the water level of the reservoir is the same at one time-epoch (e.g., using the average height along the altimetry track from one acquisition)? Or should some other requirements be met when we use the average height to estimate the water volume in the reservoir?
Answer 6: Information we have now (extent and average height) is what we use to estimate volume. In situ data is important to verify.

Question 7: Assuming one has access to both radar altimeter and LiDAR data, is the radar altimeter preferred for water level measurements?
Answer 7: Next week we will cover LiDAR. Airborne LiDAR may give better measurements compared to radar for smaller bodies.

Question 8: Can the altimeter be used for monitoring tsunamis?
Answer 8: Yes, we believe so.

Question 9: Is the data of SARAL/Altika free to download and use for research and academic purposes?
Answer 9: Yes, data products derived from SARAL/Altika are free to download and use for research and academic purposes. Below is a link to learn more:
https://www.aviso.altimetry.fr/fileadmin/documents/data/tools/SARAL_Altika_products_handbook.pdf

Question 10: Can we estimate silt deposition in reservoirs?
Answer 10: Using optical imagery extent of silt deposition may be observed, but using altimeter data, you will not be able to estimate silt deposition in reservoirs.

Question 11: Laser altimetry (ICESat-2) with its multiple parallel beams can overcome some of the limitations of radar altimetry. Will this be mentioned?
Answer 11: Please tune in for Part 3 next week.

Question 12: Is there a list of lakes which will be included in the water level monitoring network? And what would be the spatial resolution?
Answer 12: Now, all lakes over 100 km^2 are included in the water level monitoring network. Smaller lakes are being included over time.

Question 13: Some known lakes in my country haven't been captured, what is the reason? Is it the area, depth, or other reasons for this?
Answer 13: Primarily, it would be area.

Question 14: Can we use the altimeter data for monitoring lakes in mountainous regions like the Himalayas?
Answer 14: One limitation is the complex topography due to the radar echo.

Question 15: Could the use of the radar altimetry technique confuse lake shores with wet soils?
Answer 15: Altimetry data may not be included over a coastal area. The SWOT mission will cover coastal regions.

Question 16: Is G-REALM already calibrated with in-gauge station data? Also, is it available to obtain data in G-REALM in table format (e.g., csv format)?
Answer 16: We are not certain every lake is calibrated with in-gauge station data, only those with in situ measurements. It is possible to obtain G-REALM data in csv format.

Question 17: Why is lake height positive and negative?
Answer 17: Lake height is represented as positive and negative because it is a variation to a reference, not an absolute height.

Question 18: How long does it take for the radar signal to travel from the satellite to the earth's surface and back?
Answer 18: Radar waves are electromagnetic waves that travel at the speed of light (300,000 km/s), so you can calculate the time based on the altitude of the satellite in its orbit.

Question 19: Are there any data sources similar to G- REALM available for smaller lakes? For those not covered under G- REALM?
Answer 19: Not that we are aware of (based off of altimeter data).

Question 20: What is the criteria for which lakes are chosen to monitor? I see very few European lakes. Is this bound to change or is there any other platform which has other data available?
Answer 20: Lakes are chosen based on agricultural importance.

Question 21: How do you get data in lakes and reservoirs not in the list? For example, I don't see lake points in the Philippines.
Answer 21: You will have to derive for yourself. The technique is validated, see the tutorial and Birkett papers for methodology (slide 42 in the presentation).

Question 22: How does one calculate the mean lake level? Does this mean more than one satellite pass? Do you have other means to measure the mean?
Answer 22: Samples over time are averaged.

Question 23: Do you have GEE code for accessing lake heights?
Answer 23: As of today (Feb 17, 2021) the datasets covered today have not been uploaded into GEE. We hope they will be included in the near future.

Question 24: How do you account for missing values?
Answer 24: To account for missing values one can use interpolation or in situ measurements.

Question 25: Does the radar altimetry on the satellite measure along a single line only or are there data from several line transects along the lake? I ask because lake bottoms have varying topography just like on land.
Answer 25: Yes, over time there are multiple swaths.

Question 26: Why is the Ka band in the microwave region more preferable over other bands such as C or X band?
Answer 26: If you are referring to Sentinel-6 (that has Ka Band), it could be due to the wider swath.

Question 27: Is there any way to measure the height of lakes/dams less than 100 km^2?
Answer 27: No, not with the current altimeters flying on satellites.

Question 27: Is it possible to measure lake level variations of small lakes using SWOT or any other existing mission?
Answer 28: You can use some existing satellites to measure lake level variations of small lakes, but for lakes less than 50 km^2, SWOT will be able to resolve. The SWOT satellite is set to survey the height, area, and changes in volume over time in lakes with a surface area of 6 hectares (15 acres) or more (i.e., an outline of 250 m by 250 m or 820 ft by 820 ft).

Question 29: Should we consider one satellite measurement or more than one for the same lake? What do you recommend?
Answer 29: For height, it would be better to combine all available data.

Question 30: How do you perform an accuracy assessment to validate the results when working with radar altimetry?
Answer 30: You perform an accuracy assessment by comparing with in situ data (i.e., gauge data).

Question 31: Is there any calibration differences between altimeters (e.g., between TOPEX/Jason-1/2/3)?
Answer 31: Jason 2 and 3 (Poseidon-3 & Poseidon-3B) have better accuracy (calibration) compared to TOPEX/Poseidon and Jason-1 (Poseidon-2).

Question 32: How can we access Sentinel-6 data?
Answer 32: Sentinel-6 data is not available yet.

Question 33: Satellites that will gauge river discharge and height, does it include every type of river? For example, how much precisely will it be in the case of mountain rivers, with higher-velocity flow?
Answer 33: Complex topography will affect precision and coverage.

Question 34: Radar altimetry measures sea surface topography; we have satellite ellipsoidal height, we get mean sea level height at the end of the study. How do we get precise undulation information to conclude that result?
Answer 34: Time series (multiple measurements over time) can address this.

Question 35: Must we use specialized software to process the data collected by radar altimeter in order to get the height? Could you mention a few of them?
Answer 35: Tutorials from ESA and CNES can be used:
http://www.altimetry.info/radar-altimetry-tutorial/data-flow/data-processing/
http://www.altimetry.info/radar-altimetry-tutorial/training-material/

Question 36: Can the altimeter be used for extracting the bathymetry of lakes?
Answer 36: In Part 3 we will cover using ICESat-2 for extracting the bathymetry of lakes.

Question 37: I noticed many lakes and reservoirs in the western US are missing from the G-REALM site that seem to meet the minimum 50-100 square km limit. Is there a simple explanation for that?
Answer 37: It is likely application based decisions to include or not.

Question 38: Can altimeters be used for detection of shoreline positions?
Answer 38: You will need optical imagery (vs altimetry)

Question 39: How effective are these altimeter measurements for water levels of estuaries?
Answer 39: Look for SWOT datasets once they become available. Size of the area of interest will continue to be an issue.

Question 40: Can we download yearly data from global surface water? When I am downloading it comes in a tiff file for 2019 only. How can I change it for in-between data download (from 1984 to 2019).
Answer 40: Using JRC's global surface water, you have options of analysis ready products such as monthly and annual datasets. These will allow you to select individual months and years for your study area/period.
https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_2_YearlyHistory#description
https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_2_MonthlyHistory

Question 41: Is it possible to monitor water level height under the forest cover?
Answer 41: The SWOT global water monitor will cover wetlands, but in forest, the cover may prove to be problematic with altimetry.

Question 1: At what frequency is the altimetry data available?
Answer 1: For Jason-2/3 (Poseidon-3/3B) it is the Ku band (13.6 GHz) and C band (5.3 GHz).

Question 2: Are data available for West Africa?
Answer 2: Yes, data are available for West Africa.

Question 3: Is it possible, in your opinion, to measure the height of small artificial lakes used by firefighters during periods of drought to put out fires?

Answer 3: Limitations include 100 km spatial resolution. It is possible for people to monitor small lakes exclusively.

Question 4: I was wondering if you know whether SWOT data will be publicly available or not?
Answer 4: The data will be publically available. On their website, there is an early adopter program to gain access to datasets and software.
https://swot.jpl.nasa.gov/

Question 5: Is it possible to download the altimeter data as a csv, or is it only available as a text file?
Answer 5: Yes, it is available as a text file.

Question 6: What is the process regarding questions 27? (To request the data.)
Answer 6: You can find level 1 & 2 data on the JPL site which is provided below.
https://podaac.jpl.nasa.gov/datasetlist?ids=&values=&search=Altimeter&view=list&provider=

Question 7: What is the best platform to manage altimetry data?
Answer 7: Current platforms that are best to look at altimetry data are Jason-2/3, Sentinel-3, and SARAL/AltiKa.

Question 8: I would like to have more details about SWOT launching and its coverage, temporal resolution. Thank you.
Answer 8: It is a year out, so information will be limited, but resources are available.
https://swot.jpl.nasa.gov/
Contact: Margaret Srinivasan: margaret.srinivasan@jpl.nasa.gov

Question 9: It will be a very basic question, but what is the basic principle in processing altimeter data? Are there any similarities to optical image processing? Or is it similar to RADAR image processing methods?
Answer 9: At nadir, you will get a radar echo and it is different from processing optical imagery.

Question 10: What software can be used to process altimeter data? What kind of interaction can we expect if the lake or swamp surface area falls below 50 km^2?
Answer 10: If it is a smaller lake, the data will not be as accurate. Refer to the tutorial in the presentation:

http://www.altimetry.info/radar-altimetry-tutorial/training-material/

Question 11: When you were speaking about temporal and spatial resolution, you said that for NASA/CNES series, the spatial resolution is 10 days. Shouldn't that be the temporal resolution?
Answer 11: I misspoke. Yes, the temporal resolution is 10 days.

Question 12: Is there a direct connection to the data in global_reservoir, so it does not need to be downloaded?
Answer 12: Currently the data for global reservoirs has to be downloaded. There are datasets on GEE for data exploration and analysis, but they contain both natural lakes and human made reservoirs.
https://developers.google.com/earth-engine/datasets/catalog
https://developers.google.com/earth-engine/datasets/catalog/JRC_GSW1_2_GlobalSurfaceWater

Question 13: Why is the limitation here at 100 km? I remember in the past session they got to 10 km. Is it the problem in limiting the contour of the lake or the height?
Answer 13: We did reference 10 days over 100 km, but not 10 km in regards to horizontal extent. We also did not reference altimeter data.

Question 14: Are you able to georeference the lake with a local coordinate system? Or is there a uniformed system that is used?
Answer 14: Global ake data is typically georeferenced in a geographical coordinate reference system (CRS). Once you have the data you can change the CRS and projection for your specific study area.

Question 15: Is it possible to measure the waters flowing under ice glaciers at high altitude in mountains?
Answer 15: Not with the demonstrated technique.

Question 16: When we are talking about the altimetry data are we talking just about the heights or are there other types of information in the altimetry data?
Answer 16: Altimetry data is used primarily for height.

Question 17: Is the data for download from places like G-REALM and DAHITI already calibrated? Or must it be calibrated/validated after download?

Answer 17: The data accessed from G-REALM and DAHITI is calibrated. With in situ data, outside calibration is recommended for greater accuracy.

Question 18: For some lakes I see they are missing data? What could be the potential problems related to that?
Answer 18: Either surface conditions were not derived properly or there were issues from the dataset itself.

Question 19: What is the spatial resolution of the Sentinel-3 altimeter?
Answer 19: For the SAR mode the along-track spatial resolution is 300 m. For the low resolution mode (LRM) the spatial resolution is 1.64 km.

Question 20: How can we find the causes of a change in the time series of lakes (e.g., what happened in one year in the past that impacts the water level in lakes)? Because my research is in another location, using Landsat data showed the lowest water level in 2014, the same with the research example using Jason.
Answer 20: Looking at lake level height, volume is affected by multiple factors, including precipitation, evapotranspiration, stream flow, etc. Water budget data is also a good tool in regards to this. Having an understanding of the referenced area will also give insight into potential issues you may be having. Under drought conditions, less precipitation is a factor as well.

Question 21: Regarding question 18, is there a way of interpolating missing data? Sometimes they are essential for some specific study field (like flood study).
Answer 21: If some steps are missing from a time series, you can interpolate. Referencing in situ data also helps as well.

Question 22: Where can I learn more about the ionosphere and troposphere corrections used on the G-REALM website?
Answer 22: You can reference the altimeter tutorial in the presentation and find info on the G-REALM site on the left panel.

Question 23: What kind of in situ investigations can be conducted on lakes to correlate with the data received from radar altimeters in order to increase the accuracy? Can some offshore geophysical techniques apply for example?
Answer 23: Usually gauge data is used to assess accuracy. In regards to in situ data, we will look into this further. You can also look at watershed processes as well. We are not aware of any specific techniques.

Question 24: Is the Altimetry data only available for water bodies or for other areas as well?
Answer 24: The data is available over water bodies in general, not land.

Question 25: Can the use of acquired data with drones improve accuracy assessment?
Answer 25: You can explore some papers about accuracy assessment in regards to drone imagery.
https://doi.org/10.1016/j.jhydrol.2017.02.038

Question 26: Are there options to measure altimetery for small lakes?
Answer 26: Smaller lakes are not available at the moment.

Question 27: Can you request data on bodies of water not included in the catalogs?
Answer 27: You can. Altimeter data will be made available.

Question 28: How is average height derived per pixel in altimetry? If the radar measures the echoes, how can you tell the distance per pulse with backscatter?
Answer 28: Radar/Lidar altimetry does not deal with 'pixels'. The datasets offer an average height value every 200-300m along a given ground track. The distance between instrument antenna and surface is measured via timing the return of the microwave pulse. Then knowledge of satellite orbit and other geophysical parameters is applied to determine surface height with a given datum.

Question 29: Assuming one has access to both radar altimeter and LiDAR data, is the radar altimeter preferred for water level measurements?
Answer 29: Both have advantages and limitations. Radar is all-weather while lidar cannot see through dense clouds. Radar can only deal with large water bodies while the latest lidar (e.g. ICESat-2) can see much smaller/narrow water bodies.

Question 30: Some known lakes > 100 km^2 in my country haven't been captured, what is the reason? Is it the area, depth, or other reasons for this?
Answer 30: The ability to capture a given lake depends on many factors, but primarily the altimeters are profiling meaning they only see what is directly below the satellite. Either lakes are crossed over, or they are not.

Question 31: What are the limitations when we want to apply altimetry to the coastal areas (coastal altimetry)? What are the processing steps?

Answer 31: Satellite altimetry datasets potentially offer height information near the coastline but it depends on the severity of the coast. Altimeters are not designed for rapidly varying terrain. Also, the datasets will not include local tidal information that has to be applied separately.

Question 32: Do you know methods to derive water body bathymetry if you have a time series of water extent and water level? Can water storage change be accurately estimated? If you have a bathymetry model, would it be possible to get extent from level and vice versa?
Answer 32: You can determine the lake bathymetry above the water line by observing the relationship between level and extent (the Hypsometry) providing sufficient pixel resolution, or the basin shape, allows extent to be monitored. Gaining below the water line bathymetry is much trickier and you need published survey sources or DEM's (before dam completion) for this.

Question 33: Can you explain the way to read the lake heights - e.g. Lake Winnebago - via the lake variation graph - mean target height is 161.65 m. But the lake profile states mean depth is 4.7 m. Can you explain these values please?
Answer 33: Height variations (graphs) are provided with respect to a single overpass datum that is date-specific. These can then be converted to a Reference Ellipsoid (geodetic) datum and a Mean Sea Level (orthometric) datum. See the Frequently Asked Questions document on the G-REALM web site:
https://ipad.fas.usda.gov/cropexplorer/global_reservoir/faq.aspx

Question 34:What is the resolution for the lake surface? How is altimeter data influenced by temporal resolution?
Answer 34: Resolution a few hundred meters for the radar altimeters, much finer for the lidar altimeters. Temporal resolution is set by the missions, 10-35days.

Question 35: What is the minimum depth of the water body that can be studied from an altimeter?
Answer 35: Depth is not an issue providing that dry land surface does not dominate the footprint. Capturing seasonality is more of a problem if it drops to 25cm or less per year.