Questions & Answers Part 1 (Session A)

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: Will salinity assessment be covered in one of the other sessions?
Answer 1: No, salinity is not covered in this training.

Question 2: Why do I sometimes see Sentinel-2 has a revisit time of 2 or 3 days?
Answer 2: With coverage from both Sentinel-2A and -2B, and also depending on the latitude, it is possible to get a 2-3 day revisit time.

Question 3: Doesn't OLCI have a 1-2 day revisit time?
Answer 3: OLCI provides daily data – but the revisit time, exact scene is covered every 27 days. There are sub-cycles over Europe also. For information please see: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-altimetry/coverage/revisit-time#:~:text=The%20SENTINEL%2D3%20orbit%20has,as%20described%20in%20Table%201.

Question 4: I'm working with S3_OLCI, and the revisit time (with both satellites) is just 1 day for Europe. Is it the same for the rest of the world?
Answer 4: Yes, OLCI swaths are wide and you can get daily data, but exact scenes will be repeated less frequently. For information please see: https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-altimetry/coverage/revisit-time#:~:text=The%20SENTINEL%2D3%20orbit%20has,as%20described%20in%20Table%201.

Question 5: What is TOA radiance?
Answer 5: TOA is Top-Of-Atmosphere radiance data. That is what a satellite sensor would measure. TOA shows combined contributions from surface and atmosphere.

Question 6: Would we be able to differentiate between floating vegetation and open water using the satellite data? It has been done with optical and Synthetic Aperture Radar (SAR) data.
Answer 6: From optical data, it would be difficult. We will look into this further.

Question 7: Why is water-leaving reflectance defined differently from the regular definition of reflection? What is the need for such a definition?
Answer 7: That is to distinguish it from Top-Of-Atmosphere reflectance. Water-leaving reflectance is corrected for atmospheric contribution.

Question 8: What is the purpose of algorithm development and what does it mean?
Answer 8: Algorithm development is to find the relationship between water quality data from water samples and water-leaving spectral reflectance data. For a water body, once you have an algorithm derived from the past time series of data, you can apply it to current and near-real time satellite images to estimate water quality in that waterbody.

Question 9: Can the basic code in GEE or in other languages for retrieving water-leaving reflectance be shared? A sensor like MSI provides only basic reflectance and not water-leaving reflectance.
Answer 9: There is NASA SeaDAS/OCSSW software (https://seadas.gsfc.nasa.gov/) that provides code to get water-leaving reflectance. In GEE the data we showed for MSI and OLI are water-leaving reflectances, already derived from TOA.

Question 10: Is this data open access over the world or only for US applications?
Answer 10: The satellite data we showed are open access and global. GLORIA data are global, for a limited number lakes.

Question 11: To monitor sedimentation deposits in a dam, we used multi-date images. How do we measure the height of these deposits with satellite images?
Answer 11: We will look into this further.

Question 12: Can we monitor water quality for lakes of really small sizes, say 80/100 acres using satellite data? My experience with Landsat has been that resolution really drops at that level.

Answer 12: It is recommended that for remote sensing of water quality at least 3 pixels have to be there (clearly in the water and not covering shore). So for Landsat with 30 m that would be (0.9x0.9 km2). That is the limit of the size of a lake one can use Landsat data for.

Question 13: What do you mean by "*in situ*" data?
Answer 13: *In situ* data in this case are data derived from water samples.

Question 14: Can an individual contribute to GLORIA datasets, *in situ* water quality?
Answer 14: You may want to contact Dr. Nima Pahlevan (nima.pahlevan@nasa.gov) to find out more about this.

Question 15: A lot of water quality data is published as lake averages not tied to a specific GPS location on the lake. Can this data still be useful for RS algorithms?
Answer 15: Yes, one can use lake-average data to develop an algorithm if satellite data are also averaged over the lake – but then you only get the average water quality estimate of the lake.

Question 16: Why is dissolved oxygen not measured in these datasets or platforms like GLORIA?
Answer 16: That is a good question! GLORIA water sample data are basically when hyperspectral reflectance was measured, only parameters like water color are measured.

Question 17: What is the difference between TSS and TSM?
Answer 17: Total Suspended Solids (TSS) and Total Suspended Matter (TSM) depends on the type of sediment.

Question 18: What if there is no *in situ* data? Can analysis be continued without it?
Answer 18: Water quality parameters from MODIS and VIIRS are not available everywhere and can have varying levels of accuracy. *In situ* data can help supplement potential gaps in your data.

Question 19: How do we get water-leaving values from Sentinel-2 or Landsat 8/9 using data from GEE?
Answer 19: Current reflectance data is surface reflectance data.

Question 20: I tried selecting a different AOI for Exercise 3. When I modified the date to check if there are available satellite data, following Exercise 1, there were no satellite data shown. What did I do wrong?
Answer 20: Perhaps a different date range may alleviate your issue.

Question 21: Cloud masking is a common process, and haze removal is encompassed within atmospheric corrections – but is there a line between the two? For instance, is there a threshold between 'thin' clouds that can be atmospherically corrected, or 'thick' clouds that need to be masked? Similarly, is there a threshold for 'translucent' haze that can be corrected, or more severe haze that is either opaque, or reduces the quality of the underlying data enough to disqualify any analysis on that image?
Answer 21: There are several atmospheric correction models and they all have different features. Between thick and thin clouds, there is a distinguished threshold. We will look further into the haze aspect of your question.

Question 22: What is the use of scaling factors for Landsat 8 and Sentinel-3? Can you please provide some details? What do they do and why is it important?
Answer 22: Scaling factors are there so that the data can be scored easily. Scale factor is the factor that converts digital numbers to reflectance data.

Question 23: Should we always use TOA for Landsat and Copernicus images?
Answer 23: For water quality, surface reflectance is what you want. Copernicus Science data hub has surface reflectance.

Question 24: Do we need to apply scaling factors for Landsat 5 & 7? We are considering Landsat 5 for time series data.
Answer 24: Yes the factors are there. USGS has information about each satellite and scale factor.

Question 25: If we are using both Landsat 8 (30 meter resolution) and Sentinel-2 (10 meter resolution) on a single project, how can we validate the data, where both spatial resolutions are different?
Answer 25: For algorithm development, you would pick one resolution. GEE picks resolution automatically and rescales accordingly.

Question 26: For step 7 of the exercise, does it matter if we take a screenshot of the image in full screen view? Or should it just be a screenshot of it in the regular GEE API including the code box?
Answer 26: Zooming in is fine too.

Question 27: This is my first time seeing the GEE interface. I have been using ArcMap and ArcGIS Pro for my remote sensing tasks, and I have found them interesting. The GEE interface looks intimidating to me, and I would like to ask if one can use either ArcGIS Pro to perform the analysis and arrive at the same results.
Answer 27: You can use any platform. The main difference with GEE is that you do not have to download imagery since it is available within the repository and you can analyze and write code before downloading it. JavaScript can be intimidating but there are several resources that can help.

Question 28: For Exercise 1A, the satellite images did not cover the whole study area, is this normal?
Answer 28: It is possible that the whole study area is not covered.

Question 29: My AOI is not that big, it's a wetland. What type of *in situ* data can we collect to measure the quality of water, and then use remote sensing/GIS vice versa to verify both of them? Please tell us more indices that we can calculate.
Answer 29: Here is an example of wetland water quality assessment using in situ and Sentinel-2 data (highest publicly available spatial resolution). This paper also provides a list of several in situ data collected in a wetland area.
https://link.springer.com/article/10.1007/s13762-020-02988-3

Question 30: How can we use radar data to measure water quality pollutants, turbidity, etc.?

Answer 30: Here is an example where rainfall from surface radar has been used to get water turbidity: DOI: https://doi.org/10.2489/jswc.74.2.101

This study uses Sentinel-2 optical and Sentinel-1 radar data for detecting water quality: DOI: https://doi.org/10.1007/s12665-021-09904-z

Question 31: Instead of using L2 standard scenes, is it possible to perform case 2 water-specific atmospheric correction algorithms with GEE, as those included in SNAP for optically complex waters?
Answer 31: You are using the surface reflectance data that is within GEE.

Question 32: As you mentioned, we are using the Surface Reflectance product of S2 images. Are these data reliable, because they are designed for land applications?
Answer 32: Landsat and Sentinel-2 were designed for land applications, but can detect changes in surface reflectance on water.

Question 33: Is there a Python code to automatically line up *in situ* data with satellite overpasses?
Answer 33: There is no open source python code from NASA co-locating satellite and in situ data that we know. But satellite overpass predictor is available online (https://oceandata.sci.gsfc.nasa.gov/overpass_pred/) where you can get the time of overpass in the area of your interest. You can either plan in situ data gathering at the time of satellite overpasses, or if you have in situ data you can check if there are simultaneous satellite overpasses available.

Question 34: For question 6, couldn't we use the floating algae index? Is that implemented in GEE?
Answer 34: We are not aware of this being available in GEE.

Question 35: Can we monitor the heavy elements that are found in the water, such as lead, manganese, etc? And can we also evaluate these elements by knowing their quantity and quality and the extent of the damage they will cause to the water quality?
Answer 35: *In situ* data comes into play here. Identifying metals and plastics using satellite data can be difficult.

Question 36: If we have a list of lakes, do you still suggest finding the overpassed images one by one (similar to what you showed here)? What if those images were very far from each other?
Answer 36: If you add several polygons, you can get images for these polygons.

Question 37: Can we relate these data for analysis related to malaria and mosquito outbreak or is it completely different?
Answer 37: Water quality itself may not be useful but water temperature and algal bloom could help. But other factors such as humidity and wind also matter.

Question 38: Is the atmospheric correction used for the S2 Level-2 data the standard one (sen2cor) or is it something specific for water bodies (e.g., C2RCC/Polymer) that we are using?
Answer 38: On GEE S2 Level-2 data are based on standard sen2cor correction.

Questions & Answers Part 1 (Session B)

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: Can you expand on how to calculate Fluorescence Line Height (FLH) as an *in situ* measurement with Rrs and Chl-a?
Answer 1: Please see https://oceancolor.gsfc.nasa.gov/resources/atbd/nflh/

Question 2: What is the spatial resolution of the SeaBASS data?
Answer 2: SeaBASS data are not in a uniform grid. They are ship or buoy measurements.

Question 3: Does hyperspectral remote sensing provide more opportunities for better water quality retrieval? Which data can be more helpful (like EMIT or DESIS)?
Answer 3: Yes, hyperspectral data can provide more information about water quality, phytoplankton species can be identified. We will talk about this more during the final session.

Question 4: In this slide example, Ethiopia did not have any things about data. Why?
Answer 4: In GLORIA data, if Ethiopian in situ measurements are not there, the data will not be available.

Question 5: Is it possible that some parts of the GEE code were phased out for newer expressions? I have seen syntax that was a few years old that no longer works in present scripts. Please explain, and if there is a reference to aid in the syntax updates.
Answer 5: It is possible that over time text can change. Changes in the JavaScript and Python API can also contribute to this.

Question 6: How can I know what (where?) images are so I can download them and perform calculations in other software? Where can I download the S2 and S3 images?
Answer 6: The Copernicus Science Hub can provide images and data for download.

Question 7: Why was the algorithm with Sentinel-2 divided by 1000?
Answer 7: The scale factor is to make the data fit nicer into the frame. Same for Landsat and S3.

Question 8: Is the scale on GEE for visualization only or can it be applied to downscale data to apply to smaller areas for pixel calculations?
Answer 8: There is a way to downscale data. You are not creating new information this way however.

Question 9: Are already developed water quality models usable globally, or are they only reliable when calibrated with local data? That's to say, do we need to develop our models for each region?
Answer 9: That is recommended. In situ data that is collected in addition to models can create more accurate data. MODIS and VIIRS use in situ data in addition to models.

Question 10: Hi, I am completely new to GEE. Does GEE have new imagery ready for download within days from when it was taken or is Earth Explorer and Copernicus still the better tool to access new data more quickly? Also, is this Sentinel-2A or -2B in the script and what level is the data? L2 for aquatic reflectance?
Answer 10: Sentinel-2 is Level 2 and 2B data. GEE does have near real time datasets, such as Landsat. You do have to download data.

Question 11: How do we take advantage of the radiometric resolution in water quality monitoring? What might be the ways to explore the radiometric resolution in GEE?
Answer 11: This review includes how improved radiometric resolution can help improve bio-optical sensing of inland waters, including detection of macrophytes (aquatic vegetation).
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/radiometric-resolution

In GEE, if you have Level-1 data, you can find the saturation flag for spectral bands – for example, Landsat Tier-1 data has this information in 'Image Property'.

For information on Landsat 8 radiometric resolution, refer to the link below: https://www.usgs.gov/landsat-missions/landsat-8#:~:text=Landsat%208%20images%20have%2015,km%20(115%20mi)%20swath.

For information on Sentinel 2 radiometric resolution, refer to the link below: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/instrument-payload/resolution-and-swath#:~:text=The%20radiometric%20resolution%20of%20SENTINEL,used%20in%20SENTINEL%2D2%20Mission.

Question 12: Please brief on some methods for field data collection of the water bodies. Where can I learn more on how the different field data from the water bodies is collected?
Answer 12: SeaBASS has information about data collected. References and collection methods are listed as well.

Question 13: What should I do if the image does not overlay the *in situ* points?
Answer 13: You can adjust the date range as well as resize your study area.

Question 14: In your experience, how effective is it to observe water quality in small streams or narrow rivers?
Answer 14: Any water body should have three clear pixels from the collection site. In datasets with larger resolutions such as MODIS and VIIRS, it is possible to miss these.

Question 15: Can you elaborate on how GEE can do "machine learning algorithm application"?
Answer 15: This is beyond the scope of this training series. Refer to our recent Machine Learning training series: https://appliedsciences.nasa.gov/join-mission/training/english/arset-fundamentals-machine-learning-earth-science

Question 16: Can we monitor water quality for the lakes affected by ocean water in estuaries?
Answer 16: You have to have *in situ* methods to develop and verify algorithms.

Question 17: Would there be any problem in generating the correlation of data *in situ* with images that represent the average reflectance of the month of data collection?
Answer 17: It might work in some water bodies, but not all. Validation is important when working with data such as this.

Question 18: Alikas et al. (2023) estimated chl-a concentration in two lakes which have different trophic status (mesotrophic vs. eutrophic). For the eutrophic lake, they stated that Level-1 Sentinel-2 and Sentinel-3 based chl-a retrieval is more robust than atmospheric corrected Level-2. Can you elaborate on why atmospheric correction is not helping here?
Answer 18: When cloud cover is present, it can be difficult to use those images, but with less cloud cover it is possible to not use Top of Atmosphere (TOA) correction.

Question 19: Can we use remote sensing calibrated models in other lakes to study water quality in lakes with few to almost no *in situ* measurements?
Answer 19: You can if you have a nearby body of water with similar characteristics. If there are *in situ* measurements available for that water body in addition to accuracy, you can do that.

Atmospheric correction is a big topic with significant research being put into it. The United States Geological Survey (USGS), NASA, and the European Space Agency (ESA) have active missions with atmospheric correction.

Question 20: In slide 28, does chlorophyll represent SAV? Because Near Infrared (NIR) is completely absorbed and there is some reflectance from Green and Red Edge Portions.
Answer 20: Not explicitly mentioned about SAV but it is possible.

Question 21: Would there be any problem in generating the correlation of data *in situ* with images that represent the average reflectance of the month of data collection?
Answer 21: Refer to the previous questions.

Question 22: How many days of water sampling are necessary to make a correlation with satellite images? Is it okay to use only one sampling day?
Answer 22: If you have collocated data from one day but use several locations in the water body, it is possible.

Question 23: Are there any plans to extend coverage or include more institutions of GLORIA?
Answer 23: Refer to the project co-lead, Nima Pahlevan (nima.pahlevan@nasa.gov)

Question 24: Can you talk about the lack of adjacency correction in atmospheric correction algorithms?
Answer 24: Below are a couple of references of how land adjacency effect is addressed: https://www.mdpi.com/2072-4292/14/8/1829 https://www.researchgate.net/publication/363877807_Atmospheric_Correction_Model_for_Water-Land_Boundary_Adjacency_Effects_in_Landsat-8_Multispectral_Images_and_Its_Impact_on_Bathymetric_Remote_Sensing

Question 25: Can euphotic depth be measured as an *in situ* parameter or only by satellite?
Answer 25: There are instruments that can go underwater and provide data from measured light.