



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 Amber McCullum (amberjean.mccullum@nasa.gov) or Juan Torres-Peréz (juan.l.torresperez@nasa.gov).

Question 1: How to control the impact of climate change on water quality?

Answer 1: There are MANY factors that impact water quality related to climate change, such as increases in extreme rainfall/runoff and increased pollutants, sediment, etc. into water bodies. Sea level rise (e.g saltwater intrusion) and drought also impact freshwater quality. Harmful algal blooms may also become more common with increased water temperatures. Satellite remote sensing can be used to monitor these changes, along with in-situ data. We have outlined a few parameters (suspended sediment, chlorophyll-a, temperature, etc.) that can be monitored with NASA Earth Observations. However, mitigation of the effects of climate change is a mult-faceted issue. Here are a few resources:

- EPA: <https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-water-resources.html>
- UNESCO: <https://en.unesco.org/waterquality-IIWQ/activities-projects/water-quality-climate-change>

Question 2: Which satellites capture the ship movement detection moving in sea and its effect for FHI (freshwater health index)?

Answer 2: In order to track ship movement you would generally need higher spatial resolution data than what NASA provides, however I believe VIIRS nighttime lights (through the Black Marble dataset) have been used to track ships. There are many other websites (commercial satellites, NGOs) that track ships. Here are some resources:

- Planet: <https://www.planet.com/markets/maritime/>
- Global Fishing Watch: <https://globalfishingwatch.org/map-and-data/technology/>
- VesselTracker: <https://www.vesseltracker.com/>
- Genscape: <https://www.genscape.com/products/maritime-vessel-tracking/vesseltrackertm-online>



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Question 3: What is the highest spatial resolution data available from NASA (current and planned)?

Answer 3: This depends on the type of data you are interested in using. If you are interested in optical data, Landsat, with a 30 m spatial resolution is commonly used. MODIS is more coarse, with a spatial resolution of 500m, or 1km depending on the product. ESA has optical sensors with higher spatial resolution (Sentinel), and there are commercial satellites with higher spatial resolution (such as WorldView-2 from Digital Globe and several small sat constellations from Planet).

Question 4: What portion of DOM is colored (CDOM)? If only CDOM is observable from remote sensing I'm wondering what proportion of total DOM in water is actually being detected using these methods?

Answer 4: It actually depends on the freshwater ecosystem that you're working with. And it will depend on the different constituents of the water column and also on the amount of detritus that is being decomposed in the water. That's some of the factors that affect CDOM in terms of its relationship with dissolved organic matter.

Question 5: Are you only using hyperspectral imaging to detect freshwater?

Answer 5: An example of this is what I talked about in the presentation, particularly for Pinto Lake in Monterey Bay in CA. We used data from AVIRIS which is an airborne sensor usually flown at high altitude - 65k feet. It's particularly useful for detecting algal blooms in lakes and freshwater systems as well as in seawater.

Question 6: Can MNDWI data can be produced from Sentinel-2?

Answer 6: Yes, see examples, below for more information.

- <https://www.mdpi.com/2072-4292/8/4/354>
- <https://www.arcgis.com/home/item.html?id=112db40d3640473aacb0d1f891462496>

Question 7: Are there any plans by NASA or ESA to capture higher resolution (5 m or less) imagery in order to support studies of water quality in river ecosystem?

Answer 7: The quick answer is no. The sensor mentioned, for instance SBG (Surface Biology and Geology) is still under the first phases of development and will have similar resolution to Landsat - about 30-60 m pixel size.



Question 8: What remotely sensed data would you use for estimating groundwater use for irrigation?

Answer 8: This is a difficult - In terms of groundwater estimation there is the GRACE-FO satellite, the Gravity Recovery and Climate Experiment. However, the spatial resolution is quite large. With GRACE what's being measured is changes in the Earth's gravitational pull. Gravitational anomalies can be translated into changes in total water storage. Using a water budget you can break it down to surface water vs. groundwater. That's over very large areas (300-400km). So it may not be useful for something like irrigation modeling.

There are other tools - like Landsat - that can monitor vegetation health, including measuring evapotranspiration. There's a tool called OpenET, which have been used by farmers in California for irrigation management. The last I'll mention is SMAP and that also measures soil moisture at large spatial resolutions - over a km. That can be used for monitoring soil moisture for large regions. See references below.

- GRACE: <https://gracefo.jpl.nasa.gov/mission/overview/>
- Landsat ET: <https://www.sciencedirect.com/science/article/pii/S0034425715302650>
- OpentET: <https://etdata.org/>
- SMAP: <https://smap.jpl.nasa.gov/>

Question 9: Can we measure Bathymetry of rivers?

Answer 9: This is from the paper I mentioned (Legleiter et al 2009) keep in mind the algorithm was developed for water systems that have very clear water. You have to be careful with that - it's only considering 2 different bands for doing the bathymetry of rivers. There are other algorithms developed. For example, that of Pan and Glennie (2015) which incorporates other bands from other parts of the visible spectrum and was particularly developed for hyperspectral data analysis using machine learning methods. It helps to differentiate between the bottom and other constituents of the water column.

Question 10: Is there a vector map of all the water streams globally? What about aquifers?

Answer 10: I would recommend a couple different ones. There's one developed by Harvard that contains data from practically all the world's rivers. You can download data from there. Harvard World Rivers: <https://worldmap.harvard.edu/maps/4854>



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Another resource is from USGS - they have different maps that include global rivers, but particularly from the U.S (<https://waterdata.usgs.gov/nwis/rt>). There is also a map of global river widths created using Landsat data (<https://science.sciencemag.org/content/361/6402/585>).

Question 11: How can we obtain the data for an aquatic body completely covered by aquatic plants like hyacinths? Can we get the data on all the parameters of aquatic ecosystems for this condition?

Answer 11: This would be a tough one. If it's covered mostly with plants you can use for instance some algorithms like LAI (leaf area index) or maybe Floating Algal Index and that would give you just the information about the composition of the plants. It would be particularly hard to get data from the water column beneath the plants or the bottom.

Question 12: What is the best resolution data spatially for N and P detection in water?

Answer 12: Here's a reference that uses Landsat data for estimating total P in rivers in China: Wu et al 2010 International Journal of Remote Sensing
<https://www.tandfonline.com/doi/full/10.1080/01431160902973873>

Question 13: For freshwater index study estimation, do we need to use multi satellite imagery and also hyperspectral analysis?

Answer 13: We will discuss the freshwater health index during session 3. There are many datasets that are included in these estimates. Stay tuned!

Question 14: I'm using Landsat data for my GIS projects apart from landsat 8, Is there is a way to estimate land surface temperature from the previous Landsat satellites...?! and I want to know if lst is a factor that affects the fresh water quality...?!

Answer 14: (Amber) Yes it can be done, see link below for paper reference.

- <https://www.mdpi.com/2072-4292/9/12/1208>
- http://rslab.gr/downloads_LandsatLST.html

Question 15: How effective would the detection be for the CDOM tracking in smaller order hillstream tributaries? I work in the high-altitude Himalaya

Answer 15: Remember that in the case of NASA data - particularly Landsat - you're using data with a spatial resolution of 30 m. If it's a really small tributary, you'll probably get influence on the pixels from whatever's covering the surrounding areas of



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those tributaries. You might get data that isn't necessarily related to the water of the tributary. In that case, it's recommended to look for alternative sources of data - or higher resolution data from other sources.

Question 16: In your view, what is the best freely available global Digital Elevation Model?

Answer 16: USGS has digital elevation models (https://www.usgs.gov/faqs/where-can-i-get-elevation-data?qt-news_science_products=7#qt-news_science_products). Our upcoming SAR training in October (to be announced) will also cover how to create DEMs from SAR data.

SAR trainings are generally under disasters and water resources - so would encourage you to take a look at those (and those also include DEMs).

Question 17: What remote sensing if any would be available for headwaters (e.g. streams of less than third order less than 10m in width)?

Answer 17: (Amber) The most commonly used sensor is Landsat, and then Aqua/Terra MODIS, and those are too coarse to study a river that narrow. I would encourage you to look into commercial sensors for that. Maybe using [Worldview-2](#), which is about 1.84m spatial resolution. In terms of studying those systems, NASA satellite data may not be your best option. But there are pros/cons to using commercial satellite information, because they're often not freely available. Another alternative is to explore the use of drone data for capturing information on smaller-scale ecosystems. Drones have also been used to monitor temperature changes in river systems.

Question 18: What type of satellite products would be recommendable for detecting plants washed out by the Amazon River to the sea.

Answer 18: Landsat (30 m resolution) could be an alternative as well as Sentinel data. If you're thinking about a high amount of plants being washed out - for instance, know that it's not necessarily being washed by rivers - but the situation of Sargassum in the Caribbean, Landsat and MODIS have been used to track Sargassum in the Caribbean. So those can also be used to track plants washed out by rivers, like the Amazon.

Question 19: What Satellite is used for time series data for Soil Moisture for specifically for African: Soil Moisture data to monitoring and evaluating drought ?

Answer 19: Soil Moisture Active Passive via SMAP: <https://smap.jpl.nasa.gov/> Again, the spatial resolution is quite coarse, but this can be used for large region (3 to 9km).



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(Amber) SMAP is pretty coarse resolution and has a repeat time of about a week, depending on your location. You could also monitor vegetation health by MODIS (daily temporal resolution). There are additional resources that use drought indices which are generally precipitation anomalies to understand drought on a large scale. Looking at things like the Standardized Precipitation Index or the Palmer Drought Severity Index. Some of these also incorporate ground station data as well as remote sensing data. One place to look is [climate engine](#) - it's a great resource for mapping drought. It doesn't have SMAP data, but it's a good starting point.

Question 20: Where can we get the models that were mentioned (that plug into gis software) for the global flood mapping efforts?

Answer 20: InVEST is used to map ecosystem services (<https://naturalcapitalproject.stanford.edu/invest/>). May also want to look into WaterGAP (<http://www.watergap.de/>)

Question 21: What satellite data can I use to map coral reefs?

Answer 21: That's not particularly related to freshwater ecosystems - but the thing about coral reefs is that they're ecosystems that are highly diverse. So it's hard to find data that has the high spatial resolution if you want to differentiate between the different components - e.g., coral, algae. Landsat data has been used on coarser resolution. Usually there's also MODIS or VIIRS data has been used, but not necessarily to map coral reefs, but to assess water quality and relate that to the health of the ecosystem. Lately, a lot of drone data has been used for mapping at really high resolution.

Question 22: How to utilize/incorporate information from satellites such as the TRMM to quantify the amount of precipitation?]

Answer 22: [IMERG](#) is a commonly used product that integrates TRMM and GPM data. These data can be found on [Giovanni](#). Look for an IMERG focused webinar from ARSET in the next year. Also, take a look at the recordings and materials from a previous ARSET webinar on that subject: Introduction to Global Precipitation Measurement (GPM) Data and Applications (<https://arset.gsfc.nasa.gov/disasters/webinars/global-precipitation>)



Question 23: Are you aware of any models that can be used to detect nano particles?

Answer 23: Depending on the composition of the plastics, it would be how it reflects eventually to the sensor. I am not aware of any NASA work related to this, but other researchers have been using airborne data to map large plastic patches in the ocean. Here are a few references:

- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5803285/>
- <https://theoceancleanup.com/updates/remote-sensing-of-ocean-plastics/>
- <https://www.intechopen.com/books/monitoring-of-marine-pollution/detection-and-monitoring-of-marine-pollution-using-remote-sensing-technologies>
- <https://www.gislounge.com/monitoring-mapping-microplastics-marine-ecosystems/>

Question 24: I haven't tried using the coastal band of Landsat 8 but I am curious to see if it can be applied to ephemeral rivers in Southern California?

Answer 24: The use of this and other Landsat bands to ephemeral systems can be limited due to the spatial resolution of the sensor (30m) and the width of the particular ecosystem you are interested in.

Question 25: Is there a technique that allows correction of water pixels contaminated by land due to low spatial resolution of the satellite?

Answer 25: This is a common issue, called mixed pixels, when a pixel contains multiple types of components. The process to assist with this is called spectral unmixing. This can be done with a variety of statistical techniques to separate these different spectral signatures, such as principal component analysis or neural networks. Here are some more references:

- <https://www.tandfonline.com/doi/abs/10.1080/01431161.2012.661095?journalCode=tres20>
- <https://www.tandfonline.com/doi/abs/10.1080/01431169508954622>
- <https://ieeexplore.ieee.org/document/7120463>
- <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/spectral-unmixing>

Question 26: Can one use remote sensing in steep, insular canyons? Which satellite imagery would one use?



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Answer 26: Some considerations to take into account are the area of the canyons and the slope. Also, the time when the image is acquired is important since the results may be influenced by shadows caused by the canopy which might be confused with dark water pixels.

Here's a reference that used a combination of satellite and airborne data to study steep canyons and landslides:

<https://www.sciencedirect.com/science/article/pii/S0169555X06004612>

Question 27: Do you have any recommended methods/algorithms to measure CDOM or TSS from satellite imagery?

Answer 27: Yes, in the references in the last slide there are a couple studies related to CDOM. There is a complete list of references at the end of this Q & A document.

Question 28: Can we use remote sensing in designing protected areas for conservation reasons in fisheries?

Answer 28: Please tune in for Part 2 next week and Amber will begin to cover these topics.

Question 29: How would someone without much training access data products and receive training on finding and using data? Google Earth Engine? Other?

Answer 29: ARSET has many trainings available in the themes of land, water resources, air quality, and disasters. All previous trainings have the recordings, exercises available. We have had a couple GEE training and intend to have more.

Question 30: What type of resolutions have been achieved using the bathymetry mapping methods discussed. Could this be used with higher resolution plane/drone acquired imagery?

Answer 30: Some methods used Landsat data with bathymetry. Hyperspectral has been used too from CASI (spatial resolution of about 4 meters).

Question 31: How can I obtain the valor of the albedo and how this can show me degraded and / or ongoing desertification areas?

Answer 31: During the classification, be sure there are no shadows or clouds to be masked.

Here is some more information about Albedo-NDVI for desertification



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<https://www.sciencedirect.com/science/article/pii/S1878029611005135>

We can point you to the recent training in 2019 on the Trends.Earth tool for measuring and tracking desertification (<https://arset.gsfc.nasa.gov/land/webinars/land-degradation-SDGs19>)

Question 32: Is it possible to use VIS - NIR absorbance anomalies to reconstruct stream temperatures remotely?

Answer 32: Landsat has been used for this. Here are some references:

<https://www.sciencedirect.com/science/article/pii/S0303243414000075>

<https://www.sciencedirect.com/science/article/abs/pii/S0034425715300663>

Question 33: What software would you suggest to analyze freshwater, apart from GIS?

Answer 33: Open source such as Google Earth Engine and QGIS. Imagine, ERDAS, and ENVI are also used.

Question 34: In the process of land cover classification, I encountered some pixels that appeared as water-bodies whereas the actual area is not even a wetland. Could it be as a result of stormwater accumulation at the time of data collection?

Answer 34: Yes. Water is usually a dark object in imagery. Also, be sure there are no cloud shadows in your study area as these could also be interpreted as a “water body”.

Question 35: Where can one find bathymetry at 10 meters?

Answer 35: USGS may have some at 10 meters.

USGS Bathymetry data: https://nationalmap.gov/small_scale/mld/bathymi.html

NOAA Bathymetry: <https://www.ngdc.noaa.gov/mgg/bathymetry/relief.html>

Question 36: What techniques can be used to atmospherically correct inland water bodies?

Answer 36: There are multiple types of algorithms for atmospheric correction. Sun glint is often an issue with imagery over water. Here are a few references:

<https://www.sciencedirect.com/science/article/pii/S0034425719301099>

<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/atmospheric-correction>



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