Part 3 Question & Answer Session

Please type your questions in the Slido/Question & Answer Box. We will try our best to answer 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). This document will be shared to the training webpage within one week.

1. **Question: What are some of the biggest limitations engineers face when integrating NASA Earth Observation data into real-time reservoir management and hydropower operations?**
   a. Engineers face several limitations when integrating Earth observation (EO) data into real-time reservoir management and hydropower operations. One primary technical barrier is spatial resolution. Current satellite products are often too coarse (e.g., 1-10 km) for precise reservoir level monitoring, which typically requires 500-meter or better spatial resolution, and they struggle to accurately capture meteorological variables in topographically complex mountain basins. Data management and format complexities present another hurdle, as operational teams must integrate spatial files (e.g., NetCDF) into legacy databases and hydrodynamic models. Furthermore, engineers face issues with sensor continuity (e.g., MODIS to VIIRS) and validation; real-time operational models require guaranteed long-term data support, and validation delays when new satellite missions launch can disrupt day-to-day forecasting. A non-technical limitation is institutional buy-in. Dam operators who already rely on robust, triple-redundant in situ gauge networks are often hesitant to transition to satellite data, meaning training is required to help ground-based teams extract, validate, and trust remote sensing uncertainties and biases. If you have additional limitations, please send us an email.

2. **Question: Do you think that hydropower can become sustainable?**
   a. Currently, hydropower is considered as renewable but sustainability would depend on how hydropower facilities are designed, built, and operated. Traditional large-scale dams also have environmental and social impacts. If the hydropower industry prioritizes upgrading existing dams,

adopting eco-friendly technologies, and using advanced weather/climate forecasting to manage operations, hydropower may become sustainable.

3. **Question: Is the data about river discharge from SWOT ready to use? I saw a few papers using it.**
    a. The discharge data used here are not from SWOT. Researchers may have estimated discharge from SWOT data for their own areas of interest, but it is not an official SWOT product yet.

4. **Question: Is satellite altimetry accurate enough for medium-sized reservoirs like those in Burkina Faso (Bagré, Kompienga, Ziga, Bontioli), which are smaller than Lake Mead or Itaipu?**
    a. It does depend on reservoir area. For medium to small reservoirs, SWOT data might be more accurate due its higher resolution. In any case, it is recommended that the data be validated with in situ measurements if possible.

5. **Question: How should operational thresholds be defined for a multi-purpose reservoir (hydropower + irrigation + drinking water, a common case in Burkina Faso) when uses compete and multiple institutional stakeholders are involved?**
    a. While NASA provides Earth observation data and scientific insights, the agency does not prescribe water management policy; rather, these concepts serve as suggested guidelines for defining operational thresholds in multi-purpose reservoirs. Successfully managing competing demands requires balancing hydrology and diplomacy through inter-agency co-management. Before setting numerical water levels, stakeholders must agree on a prioritization hierarchy governed by national water laws. This typically places Drinking Water and Sanitation as Tier 1 (highest priority), ensuring minimum volumes are protected for human survival. Tiers 2 and 3—Hydropower and Irrigation—require negotiating economic and food security trade-offs, as hydropower depends on water elevation and flow, while irrigation requires large consumptive volumes.

       To manage these competing needs, managers can implement dynamic, seasonal allocation rather than static year-round limits. It is important to note that because local hydrology, physical capacity, and stakeholder demands differ, the specific operational thresholds and rule curves will naturally vary for each individual reservoir. Because Burkina Faso's rainy season runs only from June through October, these operational zones must adjust to efficiently capture runoff and carefully allocate supplies through the long dry season. As water levels drop from normal to critical, these thresholds trigger pre-agreed actions, such as reducing irrigation quotas or shifting power generation to peak hours. Ultimately, these suggested frameworks integrate predictive data—like upstream soil moisture and precipitation forecasts—while aggressively accounting for severe evaporation and reservoir capacity loss from sedimentation.

6. **Question: What is the most appropriate division of roles between EO, physically based models, and ML/surrogate models?**
   a. An effective modeling framework leverages the complementary strengths of Earth observation (EO), physically based models, and Machine Learning (ML) into a single, cohesive system. EO acts as the foundational observer, providing real-time spatial forcing data, initial states, and synoptic coverage to continually anchor models. Physically based models serve as the mechanistic framework, using the laws of physics to ensure mass and energy conservation, simulate unobservable subsurface processes, and reliably extrapolate unprecedented long-term climate scenarios. Meanwhile, ML and surrogate models act as the operational accelerator, rapidly emulating computationally-heavy physical models, correcting complex biases, and enabling ultra-fast, real-time decision support. Together, this hybrid approach creates a synergistic system that is observationally grounded, physically sound, and computationally fast enough for stakeholder use.

7. **Question: What about the indices NDVI, NDWI, NDSI, EVI, ET, ETa in the agriculture field?**
   a. In agriculture, Earth observation data is translated into spectral indices and physical variables to monitor crop health, manage irrigation, and forecast yields across vast scales. Vegetation indices like NDVI track overall crop health and phenology, while EVI provides improved accuracy by correcting for atmospheric interference and preventing signal saturation in dense, high-biomass canopies. To manage water effectively, NDWI measures actual liquid water within the plant canopy for early drought detection, identifying crop stress before visible damage occurs. This is complemented by physical measurements of water flux: Evapotranspiration (ET) establishes a crop's total water demand for basin-scale accounting, while Actual Evapotranspiration (ETa) reveals the

exact amount of water currently being consumed based on real-time soil moisture, enabling farmers to schedule precise irrigation and conserve scarce resources. Finally, the Normalized Difference Snow Index (NDSI) plays a crucial role in forecasting spring runoff volumes for summer irrigation supplies and monitoring insulating snow cover over winter crops. Together, these metrics form the observational backbone of modern agriculture, allowing stakeholders to optimize water use and predict regional food security.

We are having a training on ET in the coming year, and we hope whoever asked this question will join that training.

8. **Question: How accurately can satellite precipitation products represent storm magnitude, spatial variability, and accumulated rainfall over a reservoir watershed?**
    a. The accuracy of NASA's GPM IMERG product in representing rainfall over a reservoir watershed depends on the specific metric being evaluated. IMERG excels at capturing spatial variability with its roughly 10-kilometer resolution to map the continuous footprint of a storm system across an entire basin, which provides a much more comprehensive view than sparse, point-based rain gauge networks. For accumulated rainfall, IMERG's accuracy is highly dependent on the time scale; while hourly or daily estimates contain some uncertainty, monthly and seasonal accumulations are highly reliable, particularly when utilizing the IMERG "Final Run" product that retrospectively corrects satellite estimates using ground-based gauge data. However, IMERG faces its greatest challenge in accurately representing absolute storm magnitude and peak intensity. Because the satellite smooths data over its grid cells, it frequently underestimates highly localized, extreme downpours, and it often struggles to capture shallow orographic precipitation (rain or snow forced out of clouds by mountains). Ultimately, while IMERG provides reservoir managers with an excellent tool for tracking total water volume and spatial distribution over a precipitation event, capturing the exact peak intensity of a short-term flash flood still requires pairing IMERG with ground-based radar or physical stream gauges.
    Here is a link to NASA's Global Precipitation Measurement webpage to learn more: https://gpm.nasa.gov/.

    ARSET will offer a training on IMERG within the next year.

9. **Question: How was the discharge calculated? I know that we have water elevation, slope, and width from SWOT. However, to calculate discharge you need channel shape in order to determine the hydraulic radius. So, did you use a local database(s) for river channel shape/profile that was developed over time? Or have you developed a common framework internally for channel shape determination using other methods? How exactly, if I may ask? It is very interesting, to say the least.**
    a. The discharge data are from GEOGLOWS River Forecasting System and not calculated from SWOT. GEOGLOWS uses a meteorological forecast along with a hydrology model and river routing model with river geometry derived from TDX-Hydro dataset. Please see: Monitoring and Predicting Floods using NASA Earth Observations (Part 3).

10. **Question: What are the applications needed to run the codes and equations that resulted in these figures? Is it useful to evaluate the dams after they are set up for 20-30 years to find out the Environmental Impact Assessment EIA for the dams?**
    a. To run Google Earth Engine (GEE) codes and equations, you do not need to download software, because the processing occurs on Google's cloud servers, you simply need a web browser and a GEE account to use the JavaScript-based Code Editor, or a basic Python environment (like Google Colab) with the Earth Engine API. Utilizing platforms like GEE to evaluate a dam 20 to 30 years after its construction is highly valuable for conducting a retrospective Environmental Impact Assessment (EIA). While an initial EIA only predicts potential impacts, a multi-decade audit leverages vast historical satellite archives (like Landsat) to observe the actual long-term changes to the basin. This allows scientists and water managers to measure reservoir capacity loss from decades of sedimentation, track ecological shifts such as downstream wetland degradation, and update the dam's operational rules to account for modern climate realities that may differ significantly from the historical data used during its original design.

11. **Question: What is the exactitude of these data if used in other countries (runoff, rainfall, drought, etc.)?**

a. While the datasets presented have been validated in certain regions, they lack comprehensive global validation. Therefore, we highly recommend incorporating local *in situ* data to verify the accuracy of these products within your specific study area.

12. **Question: How could we get the XLS data sheet? Is it extracted from GEE code?**
    a. Only the GLDAS runoff time series was extracted from Google Earth Engine. Other time series, water surface elevation, and discharge, were downloaded in Part 2 of this training. We are happy to provide you with the CSV files directly.

13. **Question: Can we use this model in managing the Al Nahda Dam in Ethiopia?**
    a. All datasets featured in this training are global and can be effectively utilized for the Al Nahda Dam in Ethiopia. As one of the continent's largest hydroelectric dams, its large surface extent is perfectly suited for the monitoring and modeling methods discussed in this webinar.

14. **Question: Which models address the trade-offs between hydropower generation and flood control during extreme rainfall events?**
    a. While hydrological models can accurately forecast water availability during an extreme event, they do not manage the trade-offs themselves. Balancing hydropower and flood control is handled by reservoir operations models and ultimately depends on the dam's established management rules and operational policies.

15. **Question: Could you please provide the code used in Google Earth Engine?**
    a. Please refer to the training webpage to access the GitHub repository where the code is stored. You can also find links to the scripts in the PDF (presentation) found on the training page as well: https://www.earthdata.nasa.gov/learn/trainings/nasa-earth-observations-reservoir-water-utility-management.
    See Parts 2 and 3. At the bottom of the training webpage we have resources, you can also find them there.