NASA Earth Observations for Reservoir and Water Utility Management

Part 3: Applying NASA Earth Observations to Hydropower Reservoir Management

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Part 2 Review

- Search and access NASA Earth observations using Earthdata Search
- Analysis of watershed data for Lake Powell and Lake Itaipu using Google Earth Engine (GEE):
  - Precipitation (IMERG)
  - Soil Moisture (SMAP)
  - Snow Cover (MODIS/VIIRS)
  - Snow Water Equivalent (GLDAS)
  - Runoff (GLDAS)
- Examination of changing surface water elevations in Lake Powell and Lake Itaipu using Global Water Measurements (GWM) and SWOTviz.
- Examination of river inflow discharge into Lake Powell and Lake Itaipu and outflow releases using GEOGLOWS Hydroviewer.
- Assess how the watershed parameters relate to reservoir elevation changes.

Training Outline

Part 1

Data Requirements for Reservoir Management

August 4, 2026

Part 2

Accessing NASA Earth Observations for Reservoir Management

August 6, 2026

Part 3

Applying NASA Earth Observations to Hydropower Reservoir Management

August 11, 2026

Homework

Opens August 11– **Due August 25** – Posted on Training Webpage

A certificate of completion will be awarded to those who attend all live sessions and complete the homework assignment(s) before the given due date.

Part 3 Objectives

By the end of Part 3, participants will be able to:

- Analyze time series of relevant reservoir and river basin parameters.
- Demonstrate short-term (monthly) to long-term (inter-annual) variability of these parameters for selected hydropower reservoirs.

Part 3 Outline

- Overview of Lake Powell and Glen Canyon dam operations (Colorado River Basin).
- Overview of Lake Itaipu and Itaipu dam operations (Paraná River Basin).
- Analysis of time series precipitation, soil moisture, snow cover, snow water equivalent, and runoff.
- Analysis of time series of reservoir water elevation, slope, and inflow/outflow.
- Examine variability (month to interannual) of these parameters for Lake Powell and Lake Itaipu.

How to Ask Questions

- To ensure we see your question, please locate the three dots (...) at the bottom right of your training window.
- You will see a Slido/Q&A option. You may also see a standalone Slido tab or app.
- We will address **all questions relevant to the training topic** at the end of the webinar.
- Feel free to enter your questions as we go. We will try to get to all the questions during the Q&A session after the webinar.
- The remainder of the questions will be answered in the Q&A document, which will be posted to the training website about a week after the training.

Applying NASA Earth Observations to Hydropower Reservoir Management

Overview of Glen Canyon Dam Thresholds

Glen Canyon Dam

- Second largest dam in the US
- Built on Colorado River between 1957 to 1964, created Lake Powell
- 25.16 million acre-feet of water storage capacity
- Eight generators with a total capacity of 1,320 megawatts, produce around five billion kilowatt-hours of hydroelectric power annually

[Bureau of Reclamation – Colorado River Basin]

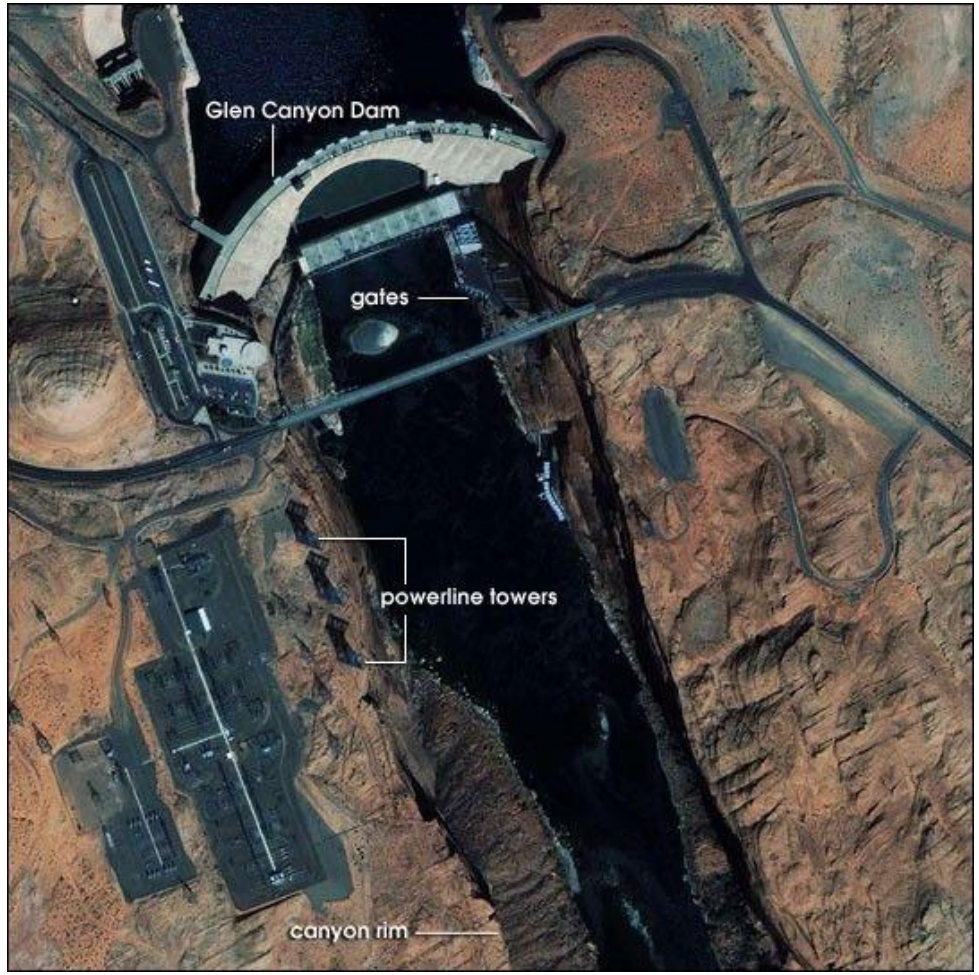


Image Credit: NASA

Overview of Lake Powell Water Thresholds

Lake Powell

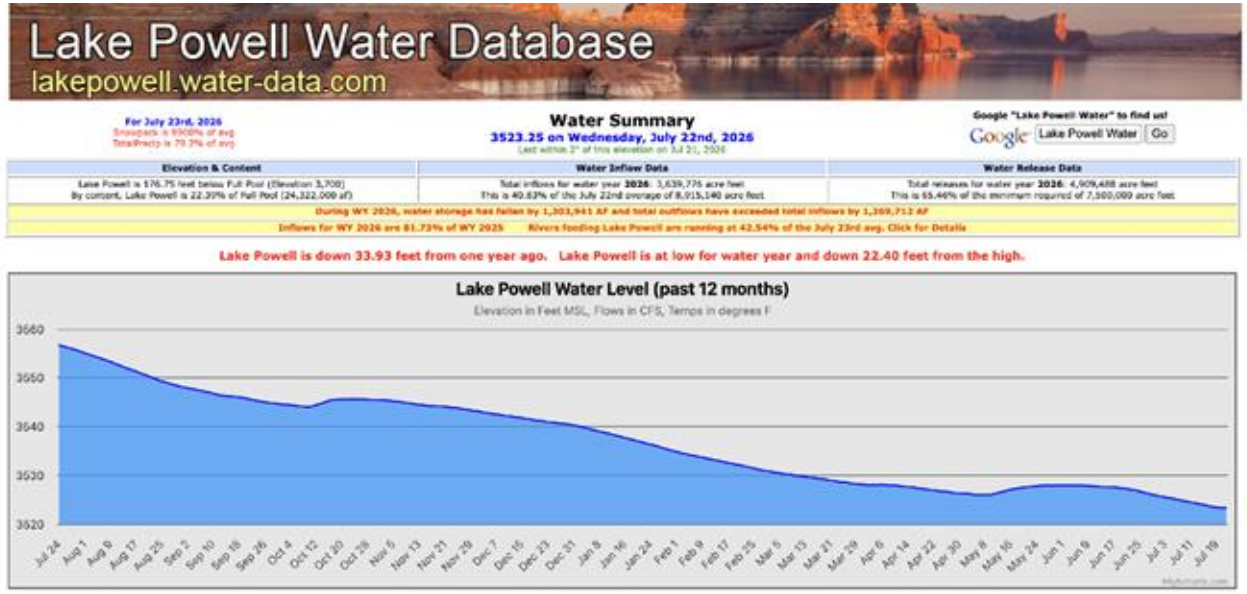
- **Surface Area:** 658 km^2
- **Full Pool:** ~3,700 feet above sea level.
- **Equalization Tier: 3,575 feet** – The level at which reservoir releases balance Lake Powell's water with Lake Mead.
- **Minimum Power Pool: 3,490 feet** – Below this level, the water pressure is insufficient to turn the hydroelectric turbines efficiently, halting power generation.
- **Dead Pool: 3,370 feet** – If water drops to this level, it can no longer flow downstream, cutting off the primary water supply to the Grand Canyon, Lake Mead, and the Lower Basin states.

Bureau of Reclamation – Colorado River Basin

Image Credit: NASA

Lake Powell Water Levels

- Lake Powell's water level increases between May and July from spring runoff and decreases during the rest of the year.
- Lake Powell is experiencing a severe water crisis in recent months.
- Unregulated inflows dropped to about 12% of average, the Bureau of Reclamation has implemented massive water transfers from the Flaming Gorge Reservoir to keep water levels from getting below the dead-pool level (USBR, April 2026).



Lake Powell Water Database

Overview of Itaipu Dam and Lake Itaipu Water Thresholds

Itaipu Dam:

- Second largest dam in the World after China's Three Gorges Dam (World Economic Forum).
- Built on Paraná river between 1975 to 1982—created Lake Itaipu, with 24 million acre-feet of water storage capacity.
- Twenty turbines with a total capacity of 14,000 megawatts, produce around 83,800 Gigawatt per hour of hydroelectric power annually.

Itaipu Binacional

Image Credit: PPIAF Global Infrastructure Hub

Overview of Itaipu Dam and Lake Itaipu Water Thresholds

Lake Itaipu:

- **Surface Area: 1,350 km^2**
- **Full Pool: ~220 meters** – (maximum 223 – 225 m) above sea level.
- **Minimum Power Pool: 197 meters** – Below this level, the water pressure is insufficient to turn the hydroelectric turbines efficiently, halting power generation.
- **Dead Pool: Below 197 meters** – If water drops to this level, it can no longer flow downstream, cutting off the primary water supply.

Itaipu Binacional

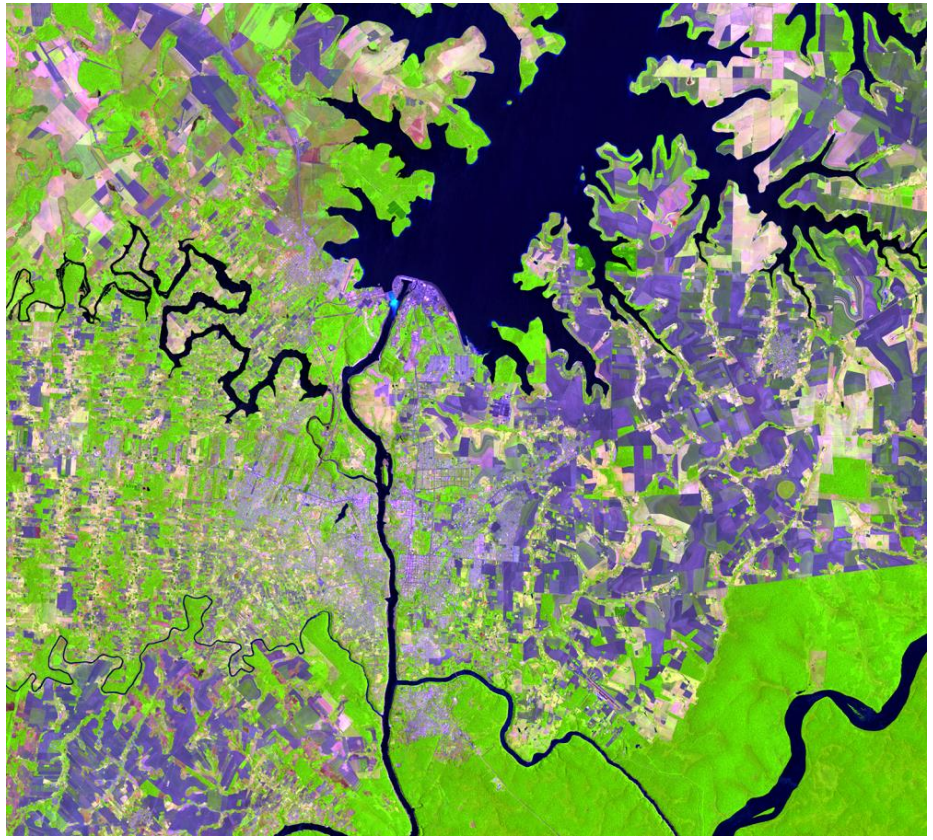
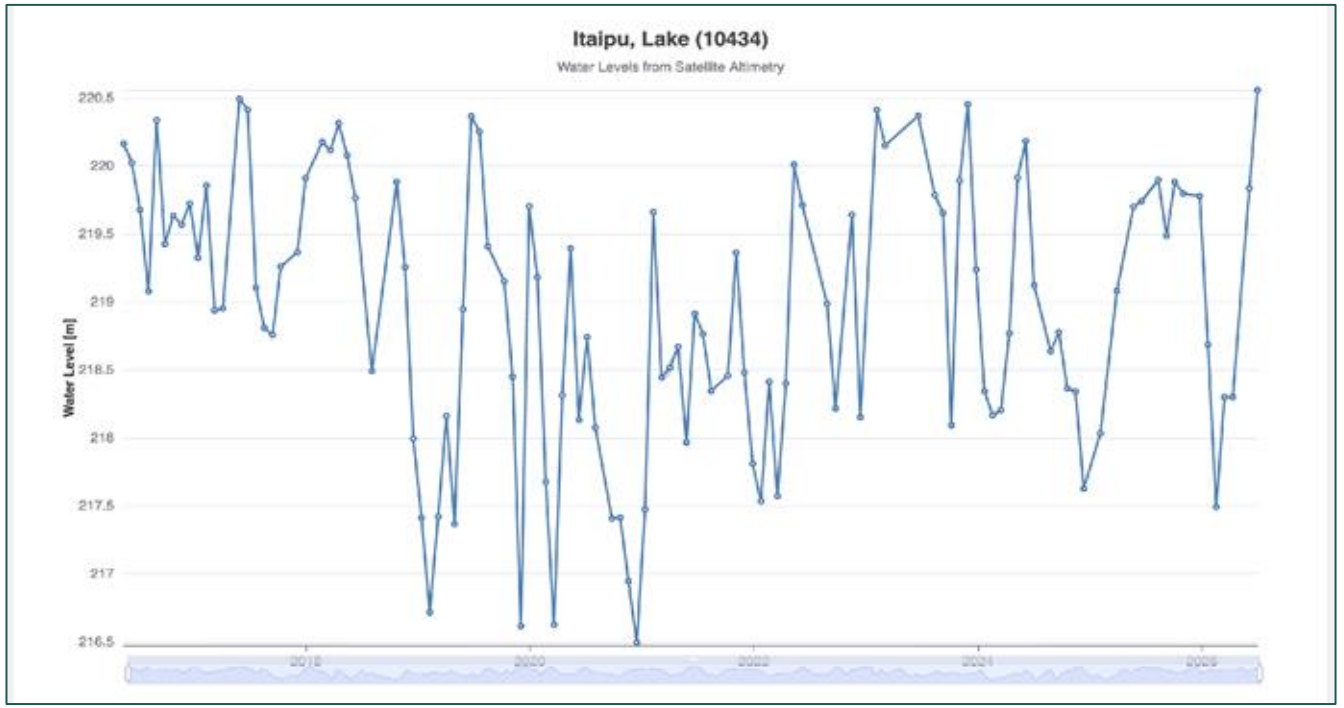


Image Credit: USGS

Lake Itaipu Water Levels

- Lake Itaipu's water level increases during February to April resulting from November to March wet season in Paraná River Basin.
- Lake Itaipu's water level height is closely regulated by Brazil and Paraguay to ensure hydropower generation and flood control.



The Database for Hydrological Time Series of Inland Waters (DAHITI)

Demonstration: Case Studies

Watershed and Reservoir Parameters During Dry and Wet Conditions

Time Series Analysis

- Using Google Earth Engine, analyze time series of precipitation, soil moisture, snow cover, snow water equivalent, and runoff.
- Using SWOTviz and GEOGLOWS, analyze time series of reservoir water elevation, slope, and inflow/outflow.
- Examine variability of these parameters for:
  - Lake Powell during 2025–2026 drought condition.
  - Lake Itaipu during November 2023 flood condition.

Case Studies using Google Earth Engine

- Case Study 1 – Lake Powell

  https://code.earthengine.google.com/378be562f250b1c4f386a068e5234cdd

- Case Study 2 – Lake Itaipu

  https://code.earthengine.google.com/42b09505286a5bb687abe131ad839500

Part 3:

Summary

Summary

- Utilize Google Earth Engine (GEE) to process continuous multiyear records of precipitation (IMERG), soil moisture (SMAP), snow cover (MODIS/VIIRS), and runoff/SWE (GLDAS), standardizing outputs.
- Generate a monthly mean climatology to establish a seasonal baseline and chart interannual variability.
- Calculate, extract, and map specific monthly anomalies (Target – Baseline) to identify significant deviations from normal watershed conditions.
- Apply Global Water Measurement, SWOTviz and GEOGLOWS to analyze time series of reservoir water elevation, slope, and inflow/outflow.
- Examine extreme weather impacts through a drought case study at Lake Powell (Colorado River Basin) for 2025–2026.
- Examine weather impacts through a case study at Lake Itaipu (Paraná River Basin) for November 2023.

NASA Earth Observations for Reservoir and Water Utility Management

Summary

Training Summary

- Managing critical reservoir infrastructure requires continuous monitoring of watershed conditions (precipitation, snow, soil moisture) and specific parameters like water levels and flow rates.
- GPM IMERG tracks extreme weather and droughts, SMAP measures soil moisture to predict if precipitation will absorb or become runoff, while LDAS integrates these observations into hydrologic models to track surface water.
- Measuring winter Snow Water Equivalent (SWE) predicts seasonal inflows, complemented by MODIS and VIIRS tracking snow cover, reservoir area, elevation, and evaporation; and OPERA tracking dynamic surface water extent.
- Using NASA Earthdata Search or Google Earth Engine, users can access and process time-series data to establish baselines and calculate anomalies that identify watershed deviations.
- Global Water Measurements, SWOTviz, and GEOGLOWS Hydroviewer are utilized to monitor changing surface water elevations and river inflow/outflow volumes.
- These integrated tools empower managers to address severe challenges, demonstrated by case studies of Lake Powell's megadrought and Lake Itaipu's extreme weather.

Training Summary

- **Available Resources:** A vast amount of open-source, long-term global datasets from NASA Earth observations and models are available, equipped with processing tools for reservoir management planning.
- **Data Integration:** Effective reservoir management requires combining these global datasets with local *in situ* data on existing practices, such as reservoir water releases, inter-basin water transfers, river basin land management, and multi-sector water allocation.
- **Upcoming ARSET Trainings:** Future advanced training sessions will focus on:
  - Utilizing short-term (hourly to 5-day) weather forecasts and long-term (sub-seasonal to seasonal) outlooks.
  - Monitoring water quantity and quality for integrated reservoir management.
  - Applying land surface, hydrology, and river routing models to plan reservoir operations.

Share Your Thoughts!

- Within a day or two, we will send you an invitation to complete a short online survey.*
- Your feedback helps us improve the ARSET program.
- Participation is optional, and all responses are confidential.
- Survey data are crucial to helping us understand how to better meet your needs. We want to help you use Earth observation data more effectively.
- We read every survey comment – so please share your thoughts!

*The survey will come from noreply@alchemer.com. This is not spam.

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Opens on 11/08/2026
  - Access from the training webpage
  - Answers must be submitted via Google Forms
  - **Due by 25/08/2026**

- **Certificate of Completion:**
  - Attend all three live webinars (attendance is recorded automatically)
  - Complete the homework assignment by the deadline
  - You will receive a certificate via email approximately two months after completion of the course.

Contact Information

Trainers:

- Amita Mehta
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- ARSET Website
- ARSET YouTube

For questions, comments, or to share how you have applied our trainings to your work or studies, email nasa.arset@gmail.com.

Join our mailing list to stay up-to-date on our latest trainings. Visit our Contact page to subscribe.

Resources

- Applied Remote Sensing Training Program (ARSET). Introduction to NASA Snow and Ice Data and Applications for Water Resources Management. (2025)
- Huffman et al. Integrated Multi-satellitE Retrievals for GPM (IMERG) Technical Documentation. (2019)
- Hydrosheds – Seamless Hydrographic Data for Global and Regional Applications
- Li et al. NASA's MODIS/VIIRS Global Water Reservoir Product Suite from Moderate Resolution Remote Sensing Data (2021)
- Lyon, Wishart, & Sohns. What's the deal with dam data? (2024)
- NASA's Earthdata Search
- NSIDC Datasets – Repository of Cryospheric Data and More
- Python Tutorial – Snow Depth and Snow Cover Data Exploration
- Schmutz & Moog. Dams: Ecological Impacts and Management. (2018)
- The National Hydrography Dataset (NHD) – Includes the Watershed Boundary Dataset (WBD)
- Water Wise School. The distribution of water on, in, and above the Earth. (2019)


APPLIED REMOTE SENSING TRAINING PROGRAM
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Thank You!