INFORMATION ITEM

Lead Scientist Report

Summary

This month's Lead Scientist Report summarizes the paper *"The Potential of Hydrogeodesy to Address Water-Related and Sustainability Challenges"* (Jaramillo et al., 2024) that highlights how satellite-based hydrogeodetic technologies can improve water management by tracking groundwater depletion, land subsidence, and water storage in aquifers, reservoirs, rivers, and wetlands. Unlike traditional optical imagery, hydrogeodesy ("the shape of water" or the science of measuring physical attributes of the earth over time) provides real-time measurements of water volume, movement and surface changes. It is particularly relevant to the Sacramento-San Joaquin Delta, where tools like altimetry, InSAR, gravimetry, and GNSS help address groundwater loss, extreme weather impacts, and equitable water distribution.

Recent Delta Science: The Potential of Hydrogeodesy to Address Water-Related and Sustainability Challenges

Jaramillo, F., Aminjafari, S., Castellazzi, P., Fleischmann, A., Fluet-Chouinard, E., Hashemi, H., et al. (2024). The potential of hydrogeodesy to address water-related and sustainability challenges. Water Resources Research, 60, e2023WR037020. https://doi.org/10.1029/2023WR037020

The Sacramento-San Joaquin Delta is no stranger to fluctuations in water availability. With increasing climatic and human pressures on this vital resource, it is imperative that we monitor these changes with accuracy and precision. The paper *"The Potential of Hydrogeodesy to Address Water-Related and Sustainability Challenges*" (Jaramillo et al., 2024) presents a meta-analysis of the science, tools, and applications of hydrogeodesy, many of which have strong potential for application in the Delta and its watersheds.

But what exactly is hydrogeodesy? While the term may be a mouthful, its concept is more straightforward. Hydrogeodesy is the science of measuring physical attributes of the earth (such as solid and aquatic surfaces, gravity fields etc.), and how they change over time. This scientific approach utilizes a slew of satellite-based technologies to track the shape, position, and movement of Earth's surface, including waterbodies. These satellites help us measure water volumes and mass across time to understand how water is stored or moved. For example, when a region experiences heavy rainfall, the ground may rise slightly as water accumulates underground, while excessive groundwater extraction can cause land surfaces to sink (subsidence). At a global scale, the melting of ice sheets can redistribute Earth's mass and subtly alter its shape, impacting rates of global sea level rise. Unlike traditional satellite images that are optical (e.g. “photographs”, that only capture surface conditions like snow presence or absence, green-ness of vegetation, etc), hydrogeodesy-relevant physical measurements from satellites provide real-time monitoring of water levels, storage, and movement across diverse waterbodies, including aquifers, reservoirs, lakes, rivers, soil moisture and wetlands.

Several types of physical remote sensing may have unfamiliar names, but the underlying technology is understood and commonly used by society today. Hydrogeodesy can be categorized into the following four types of data:

- *Altimetry:* Measures the height of land and water features, to monitor water levels in surface waters.
- *InSAR (inferometric Synthetic Aperture Radar):* Uses active radar signals to detect land deformation, helping to track subsidence, groundwater loss and floodplain shifts.
- *Gravimetry:* Measures changes in Earth’s gravity field to detect variations in total water mass (including storage in waterbodies such as groundwater, wetlands, soil moisture, lakes, rivers etc.).
- *GNSS:* Like GPS (global positioning systems), uses microwave reflections to measure land motion, subsidence and water-related surface changes.

The paper outlines numerous ways in which using hydrogeodesy can help societies answer critical, unresolved water management problems. It categorizes these challenges into seven key areas: time variability and change, space variability and scaling, variability of extremes, interfaces in hydrology, measurements and data, modeling methods, and interfaces with society. Several questions highlighted in the study are particularly relevant to the Delta and demonstrate the high potential of hydrogeodetic technology to address pressing issues. These include:

- How can we use innovative technologies to measure surface and subsurface water properties, such as how much and how it changes.
- How can we glean information from available human and water data to inform the creation of socio-hydrological models that will help predict changes in and responses to human water use.
- "How do flood-rich and drought-rich periods arise, and are they changing?"
- "What is the role of water in migration, urbanization, and the dynamics of human civilizations, and what are the implications for contemporary water management?"

These questions align with many of the Delta's ongoing challenges, such as equitable water distribution, groundwater depletion, and the impacts of extreme weather events. The authors emphasize the importance of integrating hydrogeodetic technologies into frameworks for sustainable water management, particularly in regions experiencing increased hydrological variability due to climate change and human activity. A prime example of how hydrogeodesy provides critical insights is its role in tracking where all the water went during California's 'big soak' of 2023. The 2023 big soak was a welcomed high influx of water to California after seeing an extended severe drought from 2020-2022. By using hydrogeodetic measurements, researchers were able to see how groundwater was replenished in certain areas, shifting the narrative from "water lost to the ocean" to a more nuanced understanding of water redistribution.

Despite its vast potential, hydrogeodesy remains underutilized in hydrology and water resource management. The authors call for further exploration of hydrogeodetic technologies and emphasize the need for combining multiple geodetic tools to enhance accuracy and utility. They also advocate for integrating hydrogeodesy with artificial intelligence and other Earth science disciplines to develop even more powerful analytical approaches. However, challenges remain in incorporating hydrogeodesy into educational programs and institutional decision-making. The authors propose several strategies for overcoming these barriers, including increased funding for research, broader public awareness, and policy integration.

Ultimately, the paper underscores the critical role of hydrogeodesy in tracking global changes in freshwater resources, a necessity for ensuring water security in the face of climate change. These continuous and expansive monitoring tools of physical remote sensing make hydrogeodesy not just a scientific endeavor for understanding freshwater dynamics but a useful tool for water accounting and its implications for sustainability of human and ecological systems here in California and worldwide.

Delta Science Program Activities

AGU Conference

In early December 2024, Dr. Windham-Myers attended the 2024 American Geophysical Union (AGU) Fall Meeting in Washington DC with the theme of "What's Next for Science". With over 27,000 attendees, AGU is consistently the largest meeting of earth scientists in the world. Policymakers, journalists, and educators also participate. Programming included posters, presentations, townhalls, lightning talks, exhibits and training workshops. With 28 topical areas, covering topics from the Atmosphere to Seismology to Volcanoes, the conference is a platform for interdisciplinary exploration, collaboration building, and learning new approaches. Deltas were well represented as the complex social-environmental systems they are, with at least 28 individual sessions (5-15 presentations per session) across six sections (Biogeosciences, Earth Processes, Global and Environmental Change, Hydrology, Ocean Sciences, Science and Society). Dr. Windham-Myers was involved with two sessions, one on Collaborative Science (lead organizer Dr. Laurel Larsen, former Delta Lead Scientist) and one on Coastal Carbon Cycling – and one Town Hall on the U.S. Greenhouse Gas Center. Disciplines came together in targeted co-organized sessions to tackle specific real world questions, such as California's weather whiplash and tracking effects of atmospheric rivers during "the big soak of 2023", which compliments the relevance of the highlighted paper this month. Some snapshots included here illustrate the value of in-person exchanges to learn new ways of observing, understanding and predicting patterns and responses of complex systems, such as the larger Sacramento-San Joaquin watershed and our estuary. Online access to meeting content, including uploaded posters and videos are available for viewing until February 28 (https://www.agu.org/annual-meeting/schedule).

2025 Delta Science Plan Workshop Feb 20-21

Delta Science Program staff hosted a workshop last week, February 20-21, to solicit input from the community on the development of the Delta Science Plan update. This workshop brought together speakers on the four "Grand Challenges" for Delta science including a panel on interweaving Traditional Knowledge. Council Chair Julie Lee also spoke on the importance of the Delta Science Plan for the Delta, such as coordinating for efficient and effective use of the best available science. Breakout discussions followed the speaking sessions- with both in person and online participation. Recordings of the workshop will be posted to the events webpage soon. The draft Delta Science Plan update is planned for release in fall 2025. The draft will be available for public comment period and is expected to be completed by the end of 2025.

On Your Radar

First Annual Delta Cyanobacterial Harmful Algal Bloom Workshop March 6

The Chairs of the Delta Cyanobacterial Harmful Algal Bloom Strategy Implementation Team will be hosting their first annual Delta CHAB Workshop concurrently with the IEP Workshop on March 6, 2025 (8:30 a.m. - 1:30 p.m.) in the California Natural Resources Building. Separate registration from the IEP Workshop is required to attend.

The goal of the workshop is to implement Recommendation 1.5 of the Delta CHAB Monitoring Strategy: to hold an annual meeting focusing on Delta CHABs. The workshop will focus on priority management questions around CHAB monitoring, fostering a collaborative approach to implementing the Delta CHAB Strategy, and promoting coordination, collaboration, and communication among agency and community partners. Registration for the event is available here: https://forms.office.com/Pages/ResponsePage.aspx?id=JWoY_kl95kGZQQXSKB02wRo6N_Cmi-5MqZlRJnyIOMtUREdNMzNIQzlaSTJTUkRFTkNPUVFERkgzRy4u.

Microplastic Pollution: Impact on the SF Bay Delta and Remediation Strategies

UC Davis Coastal and Marine Sciences Institute and the Delta Science Program are co-hosting a one-day symposium exploring the impacts of microplastics on aquatic ecosystems, with a focus on the heavily urbanized San Francisco Bay Delta and its diverse habitats. We will learn about how these tiny pollutants affect organisms and discuss the challenges in studying them as well as strategies for remediation and standardization. The symposium will run from 9:00 AM - 4:00 PM (PST) on Friday, May 9th, 2025 on the UC Davis campus and will also be live-streamed and recorded. This is a ticketed event for in-person and remote attendees. Registration link is available here: https://airtable.com/appEOgQ4D9g6QsZqP/pagPFvLQjDcaITtYz/form?mc_cid=b289fced42&mc_eid=UNIQID.

Golden Mussel Invasion: Status Update

Golden mussels were discovered at Rough and Ready Island near the Port of Stockton in October 2024 and have since been detected at other locations in the Delta. They are a small freshwater and brackish water mussel native to Asia. This is the first detection in North America. They likely arrived on a ship traveling from an international port. It is not known if they will cause severe problems here but based on CDFW's initial modeling, golden mussels could survive in much of the Delta as well as many lakes throughout California. They pose a threat both ecologically and economically. As filter feeders, they could cause impacts to the food web for fish and other species. Potential impacts to water infrastructure include clogging water intakes, fish screens, and other structures. They could also negatively impact recreation by encrusting watercraft hulls and engines, docks, and beaches

CDFW has convened a Golden Mussel Task Force with multiple agencies and is developing a Rapid Response Plan. Monitoring to determine the extent of the mussels is ongoing by CDFW, DWR, and other agencies. The Fish and Game Commission passed emergency regulations in December to prohibit transport and possession of golden mussels. There is no effective control method other than removing mussels when found; the mussels have microscopic floating larvae that makes controlling their spread difficult. CDFW is focusing on containing the invasion and has begun education and outreach efforts, particularly towards recreational boaters. Other locations are also taking action; for example, East Bay MUD has closed boat launches at Pardee and Camanche Reservoirs in the Sierra foothills to prevent invasion by golden mussel. CDFW and partners are expected to provide a response update at an upcoming Independent Science Board meeting this spring.

By the Numbers

Science Program staff will summarize current numbers related to Delta water and environmental management. The summary (Attachment 1) will inform the Council of recent counts, measurements, and monitoring figures driving water and environmental management issues.

List of Attachments

Attachment 1: By the Numbers

Attachment 2: Visual Summary of Article

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