EARTH

America’s hidden dam crisis revealed from space

By Reet Kaur Saturday, December 20, 2025

Virginia Tech researchers used Sentinel-1 radar satellites to identify hidden ground movement across U.S. high-hazard dams, revealing potential structural instability and urgent risks to downstream communities.

Hoover Dam panoramic view from the Arizona side showing the penstock towers, the Nevada-side spillway entrance and the Mike O'Callaghan. Credit: Kuczora

Across the United States, more than 16 700 dams are officially classified as high-hazard potential, meaning failure could result in loss of life. Over 2 500 of these structures are in poor or unsatisfactory condition.

Virginia Tech geoscientist Mohammad Khorrami said that limited funding makes it impossible to address all risks at once. “It’s difficult to address all of these dams. If you cannot financially take care of all of them at the same time, we can provide the priority dams,” he explained.

That challenge led Khorrami and his colleagues to ask whether early signs of failure might already be developing beneath the surface of existing dams. Traditional inspections focus largely on visible damage, but they often miss slow structural movement occurring deep within foundations that cannot be detected by eye.

New radar-based monitoring methods now allow scientists to detect those invisible shifts remotely, giving regulators a tool to identify the most urgent threats before failure occurs.

Detecting invisible movements from orbit

The Virginia Tech team used Interferometric Synthetic Aperture Radar (InSAR) data from the Sentinel-1 satellites operated by the European Space Agency. This technology measures ground deformation at millimetre precision by comparing radar reflections over time.

Researchers analysed a decade of data covering large hydroelectric dams taller than 15 m (50 feet). By examining how dam surfaces and surrounding terrain moved over the years, they detected gradual subsidence that may indicate internal degradation.

At the Roanoke Rapids Dam in North Carolina, the radar images revealed sinking on the northern face of the 22 m (72 feet) high structure. The pattern corresponded with cracking documented by ground inspectors, confirming that parts of the dam were settling unevenly.

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Such subsidence may seem small, but over time it can distort the concrete body or weaken the foundation. When combined with intense rainfall or rapid reservoir drawdowns, the results can be catastrophic.

Mapping risk and vulnerability together

The study's next stage integrates radar data with a wider set of social and structural indicators. By merging dam deformation records with U.S. Census data, FEMA's National Risk Index, and flood-inundation zones, the researchers built a map showing where structural decay overlaps with human vulnerability.

Preliminary findings reveal that many at-risk dams are located within 10 km (6 miles) to 50 km (31 miles) of communities with limited resources or outdated Emergency Action Plans. These areas often lack flood insurance, evacuation routes, or the funds to maintain local defences.

Khorrami noted that poor management contributes to nearly half of dam-related risk. "Almost 40 to 50 percent of this risk is in our hands," he said, pointing to maintenance and oversight as the most effective lines of prevention.

The study identifies which dams should receive top priority for federal and state rehabilitation funds. It also highlights the inequity of dam-failure exposure, which falls disproportionately on rural and low-income communities.

By combining technical and social data, the Virginia Tech team is producing the first integrated picture of national dam vulnerability—both structural and human.

Aging infrastructure under climate stress

Each surge places added pressure on concrete walls and earthen embankments. Repeated loading and unloading can erode the materials beneath the dam, worsening small weaknesses that would otherwise remain stable.

Engineers from the 1960s could not have predicted today's rainfall intensities. As storms grow more powerful, more reservoirs approach overtopping conditions, where inflow exceeds safe discharge capacity.

This convergence of aging design and climate-driven stress has made the question of dam safety not just an engineering issue but a national resilience challenge.

Remote sensing now fills a critical gap, offering continuous monitoring that no field inspection can match. Sentinel-1 passes every few days, meaning early warning could become routine rather than reactive.

Inside the AGU 2025 presentation

The findings will be presented during the AGU 2025 Annual Meeting in New Orleans, Louisiana, on December 18.

The presentation was part of a session focused on analytics and sustainability, attended by some of the 20 000 scientists participating in #AGU25.

According to the session abstract, many high-hazard hydropower dams show localized subsidence and lack updated Emergency Action Plans. These issues are especially critical in regions experiencing shifting hydrologic extremes.

The framework combines physical stability data with socio-economic indicators to guide decision-makers in prioritizing dam safety investments.

Preventing the next disaster

The United States has not suffered a major catastrophic dam failure in recent decades, but the risk remains. The 1976 Teton Dam collapse in Idaho killed 11 people and caused roughly USD 2 billion in damage. If a similar event occurred today near a population centre, the losses would be exponentially higher.

Large hydropower dams also function as key nodes for energy and water supply. Shirzaei explained that some facilities act as buffers for irrigation and electricity production. Their failure could create ripple effects across agriculture and the power grid.

Khorrami's team aims to prevent such outcomes by building a national interactive database of dam conditions, updated continuously with radar and field data. This system will be publicly accessible and used by emergency planners and engineers to identify high-priority repairs.

By focusing on prevention, the researchers hope to reduce the chances of sudden, cascading disasters. Their approach also illustrates how Earth-observation satellites can monitor not only natural hazards but the health of the infrastructure that manages them.

In the longer term, this framework could extend beyond dams to include levees, bridges, and urban flood defences—creating a comprehensive resilience network for a warming world.

Many U.S. dams are old, and some are sinking slowly. Using Sentinel-1 radar, scientists at Virginia Tech have developed a method to monitor structural movement from space. They found that several high-risk dams are close to vulnerable communities and lack modern emergency plans. By identifying these weaknesses early, authorities can focus limited funds where they will save the most lives.