R&A Explainer

How Earth's Surface and Interior are Connected to Freshwater Availability

NASA's Earth Science Research and Analysis (R&A) program's Earth Surface and Interior (ESI) focus area supports research and analysis of solid-Earth processes from crust to the core. This includes research on how the solid Earth interacts with the storage, movement, and transport of freshwater around the planet.

Freshwater often leaves a signature on Earth's surface or at depth that helps identify where it might be located. ESI uses NASA's unique, space-based observations to better identify and understand interactions between hydrologic and solid-Earth processes, which can help determine changes in freshwater stores.

Among other things, ESI's research seeks to answer 1) How tectonic processes and climate variability interact to shape Earth's surface and natural hazards, 2) How tectonic processes and climate variability interact to shape Earth's surface and create natural hazards, and 3) How the dynamics of Earth's deep interior affect what we see on the surface. Answers to these questions help bring us closer to understanding how the presence or absence of freshwater stores could shape Earth's surface.

Photograph taken by Justin Brandt, USGS, of the National Geodetic Survey vertical control bench mark H1235 RESET in Merced Country, California.

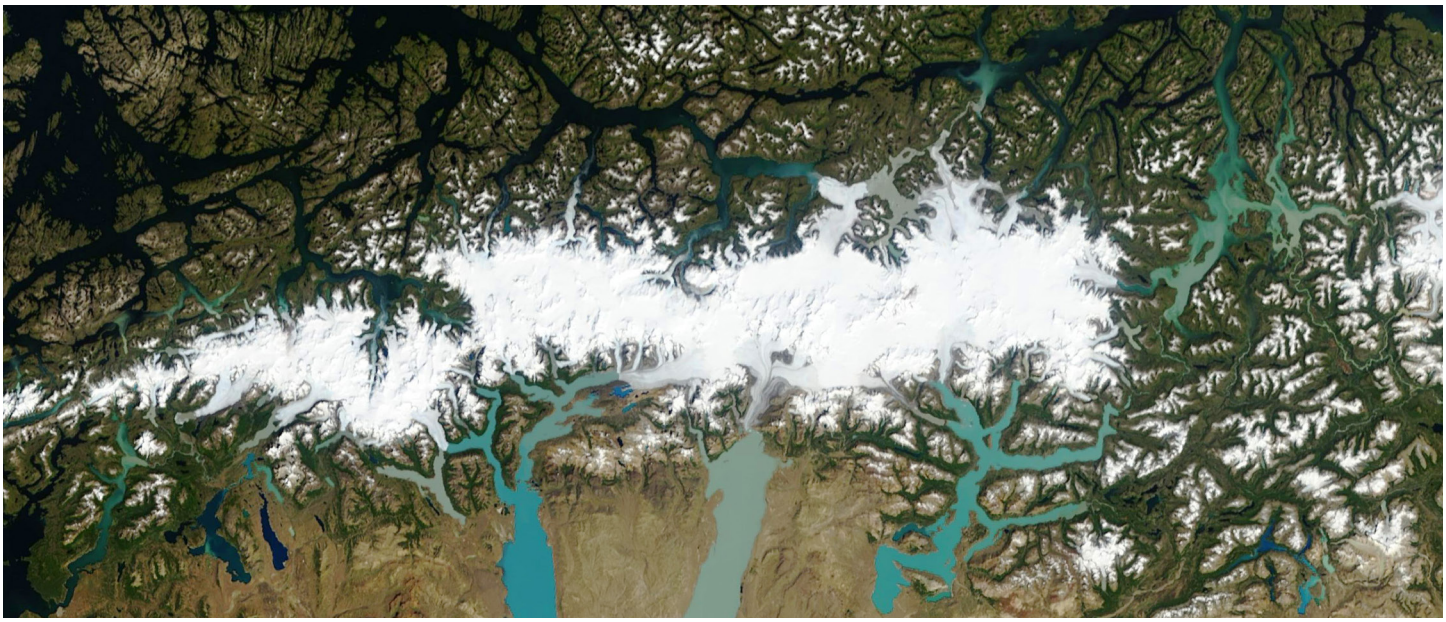
How Freshwater Affects Earth's Surface

Whether it's accumulating as snowpack in mountains or percolating deep within an aquifer, freshwater affects the land around it. ESI helps fund research that characterizes how Earth's surface reflects the changes in freshwater stores.

Highs and Lows of Groundwater

Earth's surface often reflects changes in aquifer water levels. As water levels decrease, the land above it begins to subside; as water levels increase, the land above it begins to rebound or rise. Many communities rely on underground aquifers to irrigate their crops, since aquifers provide a bank of water that can be pumped during times of drought. However, as changing climates put more stress on water-scarce regions, aquifers may soon become overdrawn and depleted. NASA satellite observations of teh solid Earth show us this connection.

- A research team used satellite interferometric synthetic-aperture radar (InSAR) data to document ground deformation across North America, some of which is suspected to be caused by groundwater extraction and aquifer refilling. (Semple et al. 2017)



Glaciers and glacial lakes in Los Glaciares National Park in Patagonia, Argentina taken by MODIS/Terra.

- An ESI-funded project created elevation maps of Tucson, Arizona, combining timeseries data of aquifer water levels with surface deformation derived from satellite data to show that artificial recharge efforts can support water management efforts. (Miller et al. 2017)

- Satellite-based Earth-observing systems detected impacts of a long-term drought in California's Central Valley and provided the most consistent, high-resolution view of its aquifer system to date. (Ojha et al. 2018)

Slippery Surface

Water influx or withdrawl on or below Earth's surface can generate changes in stress on the solid Earth, triggering movements on the surface or at depth. These movements can sometimes lead to landslides or earthquakes. Understanding when water may or may not be present in these earthen layers could help keep communities safe in the future.

- Scientists used GPS data to test their hypothesis that alternating wet and dry cycles in California affect earthquake rates. From this analysis, it was inferred that California's seismicity rates are modestly regulated by natural hydrological cycles. (Johnson et al. 2017)

- Scientists used Uninhabited Airborne Vehicle Synthetic Aperture Radar (UAVSAR) airborne and Sentinel-1A/B satellite data to document the transition of California's Mud Creek Landslide from a stable, slow-moving slide into a catastrophic one, showing how drought and extreme rains likely destabilized the slide. (Handwerger et al. 2019)

Freshwater Wobble

Satellite data on how water moves around Earth helps scientists understand why our planet wobbles on its rotational axis. For example, Earth's mantle is still readjusting to the loss of ice on North America after the last ice age, and the reduced mass beneath that continent pulls the spin axis toward Canada at the rate of a few inches per year.

- ESI-funded scientists analyzed space geodetic and satellite gravimetric data from 2003-2015 to determine that changes in terrestrial water storage and Earth's icy regions together explain nearly the entire amplitude and mean directional shift of the observed rotational axis motion. (Adhikari & Ivins, 2016)

NASA's Earth Science Research and Analysis (R&A) Program uses data and observations from satellites, airborne and ground-based instruments to advance our understanding of the integrated nature of all Earth's systems across all its focus areas: Atmospheric Composition, Carbon Cycle and Ecosystems, Climate Variability and Change, Earth Surface and Interior, Water and Energy Cycle, and Weather Dynamics and Processes. For more information, please visit https://science.nasa.gov/earth-science/programs/research-analysis