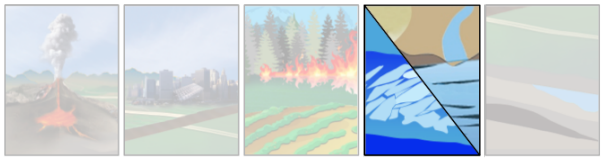
National Aeronautics and Space Administration

NISAR: The NASA-ISRO SAR Mission



Mountain Glaciers and Snow Hydrology

Glaciers and snow in mountain regions are changing drastically in the 21st century. Earth observations are crucial for quantifying how these changes impact water resources, sea level rise, and river ecosystems. NISAR can provide information about snow conditions and measure the flow of mountain glaciers over time, helping us better understand the scope and impact of change.

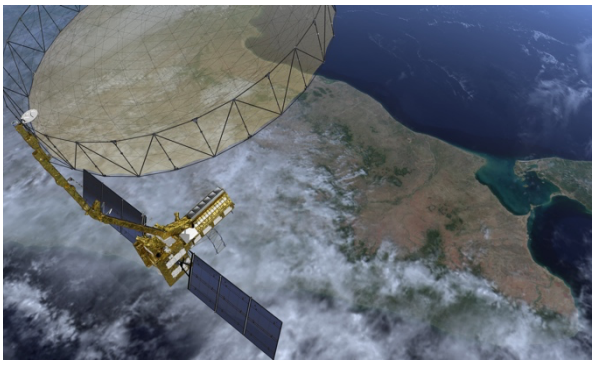
Mountain Glaciers

A glacier is a frozen river that flows downhill, where it either melts with its runoff flowing to rivers or it calves off into oceans or lakes. Glaciers, like ice sheets, form when snow does not completely melt from one year to the next. Snow builds up and becomes so heavy that it compresses into solid ice and starts to deform. Although mountain glaciers make up only 0.5% of Earth's land ice by volume, they presently comprise nearly half of the contribution to global sea level rise from land ice. The speeds at which glaciers flow, which can be visualized on velocity maps, determines how quickly they can shed water that has accumulated at high elevations. NISAR is uniquely optimized to measure the speed and changes in the speed of mountain glaciers. The combination of NISAR's long wavelength and 12-day repeat measurement time will enable comprehensive glacier velocity mapping over its mission duration. *(photo credit: Alexandra Giese)*

Mountain Glaciers and Water Supply

Mountain glaciers have been termed "reservoirs in the sky" because they modulate the timing of river flows: they melt and provide necessary water during dry and warm seasons. One quarter of the world's population depends on water supplies that originate in mountainous areas containing glaciers or snow. Melting mountain glaciers and snow sustain river ecosystems and provide freshwater for sanitation, agriculture, hydropower, and domestic use.

As glacier melt accelerates in response to anthropogenic climate change, there is an increase in meltwater until a maximum "peak water," after which the dwindling glacier size supplies less and less water to the downstream population.



The NISAR Mission – Reliable, Consistent Observations

The NASA–ISRO Synthetic Aperture Radar (NISAR) mission, a collaboration between the National Aeronautics and Space Administration (NASA) and the Indian Space Research Organization (ISRO), will provide all-weather, day/night imaging of nearly the entire land and ice masses of the Earth repeated 4-6 times per month. NISAR's orbiting radars will image at resolutions of 5-10 meters to identify and track subtle movement of the Earth's land and its sea ice, and even provide information about what is happening below the surface. Its repeated set of high resolution images can inform resource management and be used to detect small-scale changes before they are visible to the eye. Products are expected to be available 1-2 days after observation, and within hours in response to disasters, providing actionable, timely data for many applications.

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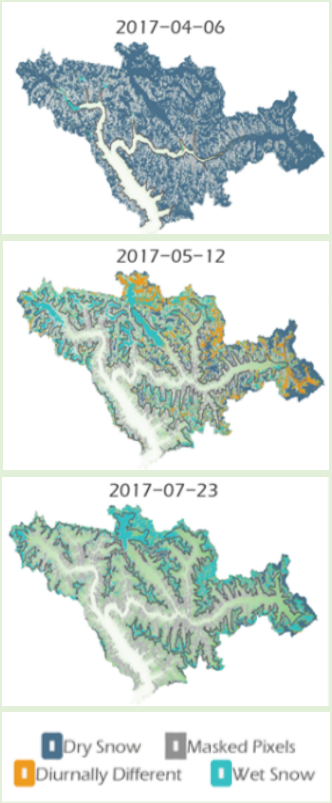
Mountain communities are already feeling the effects of rapidly changing mountain glaciers. In many countries including India, when and where ice and snow melts substantially impacts the amount and timing of river flow. Understanding and predicting the amount of this meltwater is critical for resource management and for planning mitigation measures and investments in adaptation-based infrastructure.

NISAR's regular, systematic measurements will allow global mapping of glacier velocity and tracking of melt trends through comparison of radar images taken at a sequence of times. A glacier's speed changes seasonally along with its melt. The changes in glacier speeds revealed through regular velocity mapping over years of NISAR operation will provide information critical to understanding different river basins' peak stream water flows. Information about glacier velocities, which are calculated and mapped with NISAR's images, will allow assessment of long-term freshwater resources in mountain regions.

When radar signals from the NISAR satellite reflect from the surface, part of the energy is scattered back to the satellite. The strength of this "backscatter" is affected by surface properties. The surface of a glacier can be dry snow or wet snow or bare ice—or anything in between. Different surface conditions, or "facies," return different amounts of backscatter. Because they also hold varying amounts of water, these facies contribute different amounts to river flow when they melt. By detecting changes in facies coverage over time, NISAR can inform models of glacier melt and, in doing so, provide information for calculating the flow amount and timing for mountain streams that do not have in-place water gauges to measure the flow.

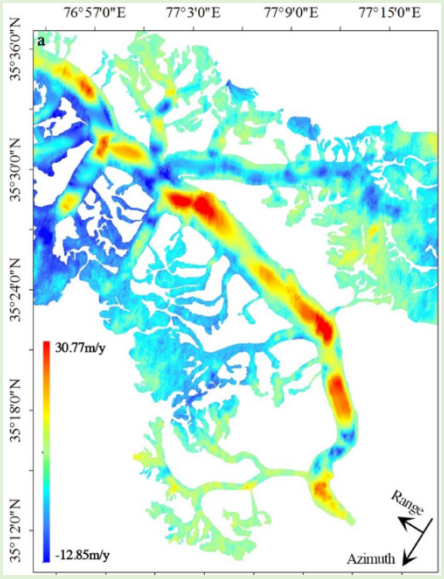
Radar mapping of mountain glaciers' snow conditions, melt, and ice velocity



The sequence of maps on the **left** shows the seasonal snow melt progression for a glacierized basin (200 x 100 km) derived from the Sentinel-1 radar. The snow and ice facies progress from dry snow, to snow that is melting during the day and refreezing at night, to consistently wet snow (*Lund et al. 2020*).

The map on the **right** shows the radar-derived ice velocity in the direction the radar is looking (range) for the Siachen Glacier in the Himalayas. The arrow in the range direction shows the general direction of ice flow. This technique can also elucidate velocity changes over time (A. Mahagaonkar, M.S. thesis, 2019).

These two applications of radar data, surface backscatter trends and ice velocity, are critical to tracking and projecting changes to the supply of freshwater and sea level contributions from mountains that sustains much of the world's economy and people. NISAR is uniquely capable of making these measurements and will provide a significant advance in our ability to measure glacier change from space.



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