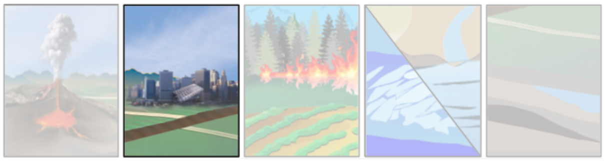
NISAR: The NASA-ISRO SAR Mission



Subsidence and a Sinking Landscape

Subsidence often goes unnoticed until the damage is done. Because land sinks too slowly or over too broad an area to be visible to the eye, the effects of subsidence are rarely recognized when they begin. Those same changes in land elevation can be detected from spaceborne synthetic aperture radar.

Subsidence: How Low Will It Go?

Subsidence, or the gradual sinking of the land surface, affects land, buildings and roads throughout the U.S. Even the Washington Monument has been affected. The iconic structure, built on the marshy shores of the Potomac River, has subsided by ~2" since its construction.

Subsidence occurs naturally in areas with high organic matter content in the soil through a combination of compaction and oxidation. For this reason, subsidence is often associated with swampy and coastal areas. However, the range of underlying causes is much more diverse, and includes geological factors, e.g., faults or sinkholes, plus a host of causes related to man's use of land and resources.   Regardless of the cause, the consequences can be severe: cracked foundations, warped roads and bridges, and more frequent flooding of cities and towns, all of which take an economic and sometimes personal toll on people.

Photos (clockwise): Carol M. Highsmith Archive/Library of Congress, Calif. DWR, USGS, NASA/JPL-Caltech

A Sinking Feeling

Land subsidence frequently occurs at a very slow rate, much too slowly to be identified visually and often only detectable by advanced sensors. It often goes unnoticed until the consequences become manifestly evident – buckling bridges, cracked foundations, the too-frequent occurrence of 100-year (or more) floods. Often at that point the processes causing the ground to sink are well underway, and damage continues to accrue before they can be stopped. This insidious hazard is both difficult to identify and costly if not discovered.

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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Subsidence is a problem that exists at different scales in numerous locations around the world. The sinking of San Francisco's Millennium Tower and across the city of New Orleans are just two examples. Decreased land elevation, the cumulative effect of long-term subsidence, has resulted in more frequent and deeper flooding. This can cause tidal waters or rainfall to generate nuisance flooding and even dangerously high water in some low-lying coastal cities. Knowledge of the extent and rate of the problem can help in making better choices for infrastructure investment and restoration activities that protect people and property. However, at the most basic level, improving resiliency and dealing with subsidence requires understanding the underlying processes driving the change, which will inform both immediate action and better modeling of future subsidence, flood risk, and ways to halt or reverse the sinking.

The sinking can be caused both by natural events and human actions, so elevation change at any given location depends on a unique set of local and regional conditions. Many measurements, spread across a broad scale and extending for a long time, are needed to tease out the relative contributions when multiple processes are involved. Human activities are often the primary contributor, including oil and gas extraction, groundwater pumping, and even drainage projects intended to reduce standing water. All of these activities can be performed in ways that do not cause damage, given proper information about the relationship between the activity and the ground movement.

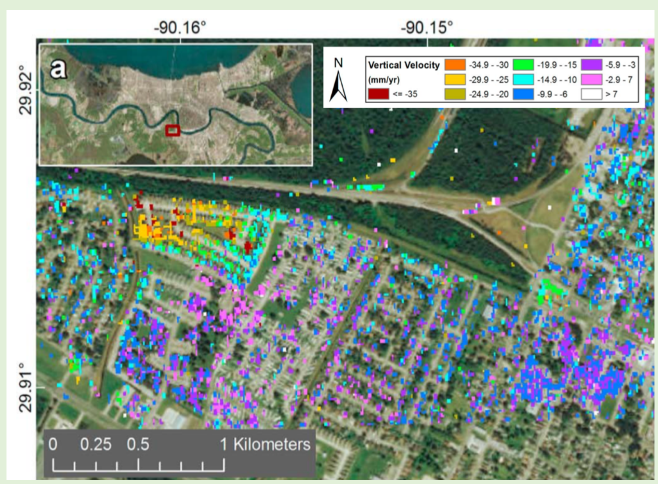
Modern radar remote sensing methods can revolutionize the way that land is monitored, significantly increasing the number of areas where subsidence rates are measured. Instead of costly in-ground instruments, satellite-based instruments can detect changes in elevation of the ground and structures across large areas via a technique called synthetic aperture radar interferometry (InSAR). InSAR relies upon repeat imaging of an area from the same vantage point in space to measure changes in the distance between the radar antenna and the ground.

To measure slow subsidence, a large number of repeated images collected at regular intervals for several years is needed. Space-based Earth observing radar instruments are able to measure subsidence hazards across a large enough region to encompass all at-risk cities in the United States. NASA's NISAR radar will be able to collect the needed images, and its products will be open access, available through the Alaska Satellite Facility.

Localized Land Subsidence Seen by Radar

New Orleans is one of the most endangered cities in the world. A large portion of the metropolitan area lies below mean sea level, while its location on the Mississippi River delta also puts it at risk of flooding both from gulf waters pushed inland during hurricanes and tropical storms, and from high water in the Mississippi River during springtime floods. Knowledge of subsidence 'hot spots' and their probable cause is particularly critical because, if undetected, unexpected flooding can endanger residents and property.

High resolution radar instruments can be used to identify the areas that are subsiding most rapidly, and can also identify subsiding or deforming structures, such as in a residential neighborhood shown at the right. In this example, radar interferometry (InSAR) shows that houses in the most recently developed area (yellow to orange) are subsiding more rapidly than houses in adjacent neighborhoods built in earlier years. This type of change could be normal consolidation of material added during construction, which would stop after a few years, or could indicate deeper, longer-lasting processes at work. Sustained, multi-year observations will provide the information needed to determine the cause.



Map showing subsidence in a suburb of New Orleans, Louisiana, produced using data from the NASA UAVSAR instrument [C. Jones et al., 2016]. UAVSAR is an airborne prototype for the upcoming NISAR mission, which will provide regularly repeated images of cities such as New Orleans.