Rapid land sinking is making many coastal cities worldwide vulnerable to sea level rise, finds international group of scientists

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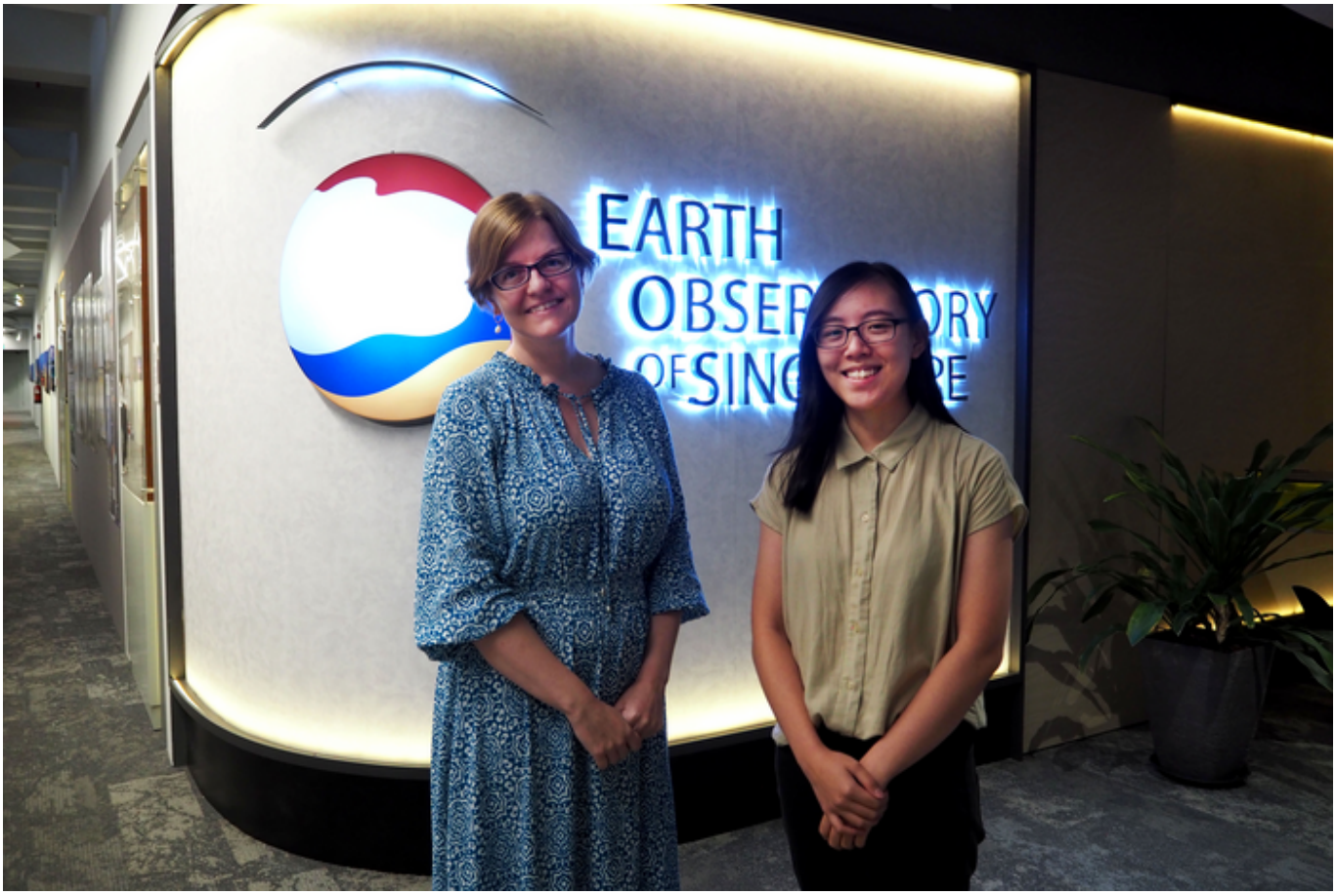
A team of international scientists led by **Nanyang Technological University, Singapore (NTU Singapore)** has found that many densely populated coastal cities worldwide are vulnerable to sea level rise because large amounts of their land are sinking. They suggest that an increase in industrial processes such as the extraction of groundwater, oil, and gas, as well as the rapid construction of buildings and other urban infrastructure may be contributing to this vulnerability.



Credit: NTU Singapore

A team of international scientists led by **Nanyang Technological University, Singapore (NTU Singapore)** has found that many densely populated coastal cities worldwide are vulnerable to sea level rise because large amounts of their land are sinking. They suggest that an increase in industrial processes such as the extraction of groundwater, oil, and gas, as well as the rapid construction of buildings and other urban infrastructure may be contributing to this vulnerability.

The team of researchers from **NTU Singapore**, **University of New Mexico, ETH Zürich, and NASA's Jet Propulsion Lab** managed by the **California Institute of Technology**, processed satellite images of 48 cities from 2014 to 2020 using a cloud-based processing system called Interferometric Synthetic Aperture Radar (InSAR).

Sea levels are rising globally as Earth's ice sheets melt and as warming sea water expands. However, according to scientists, sinking land, or land subsidence, can aggravate the problem.

Land subsidence varies at a neighbourhood and even block level but across the 48 cities surveyed, the team found a median sinking speed of 16.2 millimetres (mm) per year, while some of them have land that is sinking at 43 mm a year. The current global mean sea-level rise is 3.7 mm/year[1].

The results of the study were published in the scientific journal *Nature Sustainability* in September.

The findings are an example of research that supports the **NTU 2025 strategic plan**, which seeks to address humanity's grand challenges on sustainability and accelerate the translation of research discoveries into innovations that mitigate human impact on the environment.

This research also contributes to the **Singapore National Sea Level Programme (NSLP)** supported by the National Research Foundation, Singapore and Singapore's National Environment Agency. The research programme aims to equip policy makers with the information they need to protect Singapore's coasts.

Co-author **Professor of Earth Sciences Emma Hill, Acting Chair of the Asian School of the Environment (ASE) at NTU,** said: "In coastal areas, sinking land leads to higher sea level and an increased flood risk. Our findings enable affected communities and policymakers to identify which areas are at particular risk from high levels of land subsidence and take action to address their coastal risks."

Co-author **Assistant Professor Eric Lindsey, from the Department of Earth & Planetary Sciences at the University of New Mexico in the United States**, said: "This study highlights the value of high-resolution satellite observations for better understanding this issue – subsidence rates can vary quickly across small areas, meaning that land-based measurements often do not capture the true scale of the problem". He was a Research Fellow at **NTU's Earth Observatory of Singapore** when he participated in the study.

First author of the paper, **Ms Cheryl Tay, a PhD student at NTU's ASE and the Earth Observatory of Singapore (EOS), who was sponsored under the NSLP Programme,** said: "By estimating how much and how fast these densely populated coastal cities are subsiding, our study helps constrain projections of coastal flooding in the coming decades, as we expect more land to be flooded due to rising sea levels and land subsidence."

Southeast Asia's coastal cities sinking fastest

The 48 cities were selected based on the criteria of a minimum population of five million in 2020, and a maximum distance of 50 kilometres from the coast.

A comparison carried out by the researchers across coastal cities worldwide showed that the fastest velocities of relative local land subsidence are concentrated in Asia, especially in Southeast Asia (see Figure 1).

The researchers chose to use InSAR as it provides accurate measurements of coastal sinking to a tenth of a millimetre. InSAR maps the deformation of ground using radar images of the Earth's surface that are collected from orbiting satellites. The InSAR datasets are larger and more

accurate as unlike visible or infrared light, radar waves used by INSAR penetrate most weather clouds and are equally effective in darkness.

Ms Tay said: “Rapid sinking of the land is frequently caused by groundwater extraction. This is concerning in Asia where many coastal cities are now centres of growth, and there is high demand for groundwater extraction to meet the water needs of growing populations.”

Prof Hill added: “Without serious mitigation efforts, a combination of rising seas, large populations living on low-lying coastal lands, and sinking lands will result in devastating consequences for many Asian cities.”

“Our study highlights the fact that while this is a global issue, the response in many cases must be local. Slowing the rate of groundwater extraction to a sustainable level should be a top priority for all municipalities in coastal areas,” said **Asst Prof Lindsey.**

The researchers hope to further their study by projecting the rates of sinking land, factoring in variabilities and sensitivities from different climate and weather scenarios