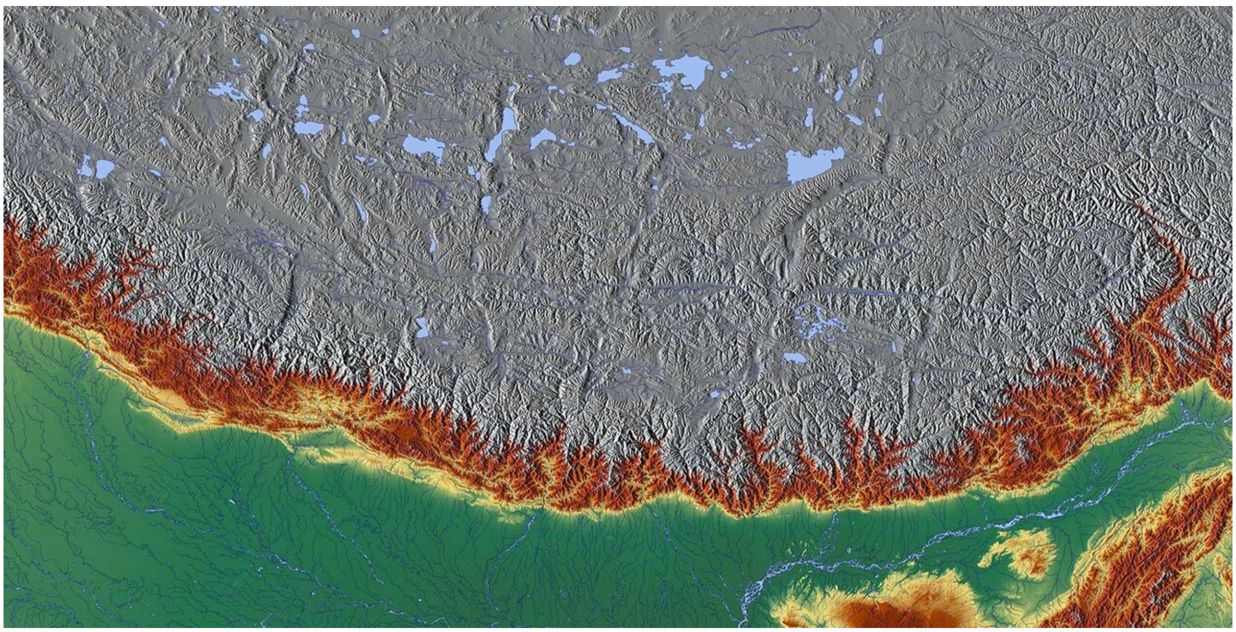
The 'breathing' Himalaya: Great mountains grow in a cycle of rising and falling

March 4 2021



Credit: www.maxpixel.net/photo-1804895

How and when do mountains grow? It is tempting to think of mountain formation as something that takes place only extremely gradually, on timescales of tens of millions of years. One tectonic plate slowly pushes up against and slightly under another, until eventually up rises a mountain range. Of course, that picture is far too simplistic. We know, for example, that processes like erosion and earthquakes affect the way mountains grow.

Synthesizing data from more than 200 studies of the Himalaya, a team led by Caltech postdoctoral fellow Luca Dal Zilio has pieced together a far more complete picture of the mountain-building process. In a review study published in the journal *Nature Reviews Earth & Environment* on May 2, Dal Zilio and his colleagues bridged timescales ranging from the seconds of shaking during an earthquake to the millions of years it takes for long-term tectonic processes to play out.

"When we think about the concept of mountains, we really need to think about something that is dynamically changing, and those changes happen at different time scales," says Dal Zilio, an Earth scientist in Caltech's Seismology Laboratory.

The researchers found that the Himalaya cycle through events that cause the range to rise and subside, rise and subside. "It's almost as though the range is breathing," says Dal Zilio. "However, the rising events over millions of years are larger than the rapid subsidence events during earthquakes. In the long run, this process leads to the growth of the Himalayan range."

The researchers focused on the wealth of geological, geophysical, and geodetic data that came out of the devastating 2015 Gorkha earthquake in Nepal and its aftershocks. For example, using radar images from satellites, scientists previously found that Mount Everest dropped by about a meter during the magnitude 7.8 temblor. But in the months following that event, scientists showed that the mountain regained roughly 60 percent of that lost elevation.

Dal Zilio and his colleagues drew on observations from the last several decades from the Himalaya, such as the thickness of the crust at different locations and what is known about the geometry of the Main Himalayan Fault, the roughly 2,000-kilometer-long fault at the base of the mountains. They were then able to simulate multiple earthquake cycles, including the so-called interseismic period between earthquakes when elastic stress slowly builds until some or all of it is released in the form of an earthquake. That allowed the researchers to see how much the various processes contributed to the growth of the mountains.

Dal Zilio has also used the model to study the earthquake cycle in the Himalaya. The 2015 Gorkha earthquake was what is called a partial rupture. It only released about half of the fault's accumulated stress. "Really we were expecting an even larger earthquake," explains Dal Zilio. "Our model is helping us understand why the partial rupture happened and what the possible scenarios are for the future."

Developing an understanding of how the Himalaya grow and change with time and how its earthquake cycle is affected is particularly important given the activity of the Main Himalayan Fault and its history of producing major earthquakes (some as large as magnitude-8.8) that affect one of the most populated regions on Earth.

The new *Nature Reviews Earth & Environment* paper is titled "Building the Himalaya from tectonic to earthquake scales."

More information: Luca Dal Zilio et al. Building the Himalaya from tectonic to earthquake scales, *Nature Reviews Earth & Environment* (2021). DOI: 10.1038/s43017-021-00143-1

Provided by California Institute of Technology