Scientists use LiDAR, 3-D modeling software to intricately map active Chinese fault zone

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Chinese and American scientists collaborating in the study of an active seismic fault that produced one of China's most deadly earthquakes say their deployment of an airborne LiDAR system, which uses pulses of laser light to calculate distances and chart terrain features, has helped them produce the most precise topographical measurements ever of the fault zone.

"Light detection and ranging (LiDAR) presents a new approach to build detailed topographic maps effectively," they report. They add that these high-precision three-dimensional models can be used to illustrate not only land surface changes following past quakes, but also features of past ruptures that could point to the possibility of future temblors.

Experts at the State Key Laboratory of Earthquake Dynamics and at the National Earthquake Infrastructure Service in Beijing, working with a colleague at the United States Geological Survey (USGS) in Pasadena, California, mounted a Leica ALS-60 LiDAR system aboard a Chinese Yun Five aircraft and then began scanning the Haiyuan fault zone in a series of flights over the course of a week. The fault zone is similar to the San Andreas fault in California, which has similarly been scanned and studied as a comparison.

"During the past century," they explain in a new study, "the Haiyuan fault zone produced two great earthquakes: the M 8.5 Haiyuan earthquake in 1920, along the eastern Haiyuan fault, and the M 8–8.3 Gulang earthquake in 1927."

"The Haiyuan earthquake of 16 December 1920 is one of the largest intra- continental earthquakes ever documented in history," they add, "and ruptured about a 237-kilometer-long ground surface, with a maximum left-lateral slip of 10.2 m, and claimed over 220,000 lives."

In the new study, "Quantitative study of tectonic geomorphology along the Haiyuan fault based on airborne LiDAR," lead scientist Jing Liu and her colleagues at the Earthquake Dynamics Lab, part of the China Earthquake Administration in Beijing, state their experiments with the LiDAR scanning system and related building of a high-resolution topographical model provide "an example of how LiDAR data may be used to improve the study of active faults and the risk assessment of related hazards."

Sections of the 3D digital model generated with the LiDAR data are "intensively analyzed to demonstrate tectonic geomorphic feature identification and displacement measurement," they state. The LiDAR data are also used, for example, to calculate horizontal and vertical coseismic offsets in one section of the fault zone.

LiDAR data can be used to verify measurements made during fieldwork on offsets of tectonic landform features, state co-authors Tao Chen, Pei Zhen Zhang, Jing Liu, Chuan You Li, and Zhi Kun Ren, along with Ken Hudnut at the USGS, who visited the China Earthquake Administration to participate in this study. "The offset landforms are visualized on an office computer workstation easily, and specialized software may be used to obtain fault displacement measurements quantitatively," they explain.

With LiDAR-generated digital models of the topography across fault zones, the "link between fault activity and large earthquakes is better recognized, as well as the potential risk for future earthquake hazards," says the team of scientists.

More precise measurements of the active fault zone made possible by the LiDAR system, and their depiction in sophisticated three-dimensional maps, are helping scientists not only in basic research, but also in terms of calculating the probability of a seismic shock recurring, say the co-authors of the new study, which was published online in the journal *Chinese Science Bulletin* by Science China Press and Springer-Verlag.

Airborne laser swath mapping helps scientists to virtually remove the vegetation covering from topographical models; this "bare earth" representation provides for more accurate identification of tectonic features and changes following a quake.

A LiDAR airborne scanning system of the Earth's terrain was deployed over the section of the southwestern Chinese province of Sichuan that was the epicenter of a Mw7.9 earthquake that struck in May of 2008; LiDAR data were used to map the scale of landslides and ultimately to develop rescue schemes.

In the new study, the Chinese and American scientists say that digital models created using LiDAR data from the Haiyuan fault zone "have a much higher resolution than existing topographic data and most aerial photographs, allowing us to map the locations of fault traces more accurately than ever."

The high level of precision of the digital models constructed with information from the LiDAR laser scans of the topography in this fault zone will encourage future "site-specific fault activity studies," state the scientists.

"In the future," they predict, "we can expect that more and more concepts or models of fault activity would benefit from this unprecedented survey technique."

Along the Haiyuan fault zone in the western Chinese province of Gansu, LiDAR scans and related digital models have already been used to identify 600 channels and other linear geomorphic features slated for more comprehensive analysis.

"The next step is to measure the displacements along the whole Haiyuan fault and analyze the principle of the slip distribution," states the team of scientists, "which would help people better understand the fundamental link between fault activity and large earthquakes and assess potential risk for future earthquake hazards."

In places where slip during past earthquakes was less pronounced, it is possible that future earthquakes could have greater slip in order to accommodate and equalize motions along the fault system. Alternatively, slip may be large repeatedly in some places and small elsewhere. Such variations in slip may help to assess future hazards, so observations of this kind are very important to answer unresolved questions that are central to research on hazards of earthquake fault zones around the world.

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