Fault geometries of two moderate earthquakes in the interior of Asia Continent revealed by InSAR

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Abstract

Intra-continental dip-slip earthquakes often occur in the orogen and rift zones with complex tectonics, providing rare opportunities to illuminate the deformation and evolution of continental structures. However, due to the sparse seismological and geodetic observations, such earthquakes are less studied. Here, we report the fault geometries of two dip-slip earthquakes recently occurred in Southern Tian Shan and the Mongolia-Baikal rift zone revealed by InSAR . The 2020 Mw6.0 Jiashi earthquake occurred in the Keping-tage fold-and-thrust belt in southwest Tian Shan. This region is seismically active, yet most well-recorded earthquakes occurred south of the mountain front. The lack of large earthquakes beneath the belt thus hinders our understanding of the orogenic process to the north. Combining InSAR measurements and relocated aftershocks, we found that a fault model involving a shallow thrust fault and two deeper faults can best reconcile the surface deformation and aftershock distribution. Stress analysis suggests that slips on the shallow fault reactivated the older basement structures at depth. Our results reflect the basement-involved shortening activated by a thin-skinned thrust faulting event with surface deformation, implying a southward orogenic process of the southwest Tian Shan. The 2021 Mw6.7 Lake Hövsgöl earthquake occurred in the Mongolia-Baikal rift zone (MBRZ), which is located in the northern tip of the northern Mongolia, and is bounded by the Tibet Plateau orogenic belt and the Siberian Platform. Using the Bayesian inversion method we derived a fault plane with two slip patches, one is mainly strike slip and the other is mainly normal slip component. The correlation between the observed and predicted displacements by the single fault model is 97.46%. Coulomb stress analysis shows that the 2021 event has a triggering effect on the western segment of the Tunka Fault to the north, where no large earthquakes have occurred since the 1905 M8+ earthquake, raising the potential for seismic risk in this region.

Causative fault geometries of two blinded earthquakes in the interior of Asia Continent revealed by InSAR

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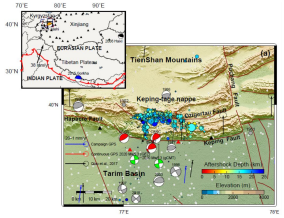
Highlights

- We report the fault geometries and slip patterns of two complex dip-slip earthquakes occurred in Southern Tian Shan and Mongolia-Baikal rift zone revealed from the radar imaging geodesy.
- The 2020 Mw6.0 Jiashi earthquake reflects the coinvolvement of thin-skinned thrusting and basement shortening in shaping the Keping-tage fold-and-thrust belt.
- The preferred fault model of the 2021 Mw6.7 Mongolia earthquake exhibits a complex slip distribution composed of two major slip asperities with normal faulting and right-lateral striking component.

2020 Mw6.0 Jiashi, Xinjiang earthquake

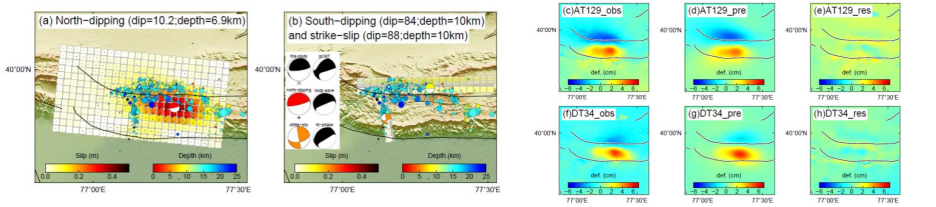
Introduction



2020 Mw6.0 Jiashi earthquake occurred in the Keping-tage fold-and-thrust belt in southwest Tian Shan. This region is seismically active, yet most well-recorded earthquakes occurred south of the mountain front. The 2020 Mw6.0 Jiashi earthquake is an important event with surface deformation in the fold-and-thrust belt well illuminated by imaging geodesy.

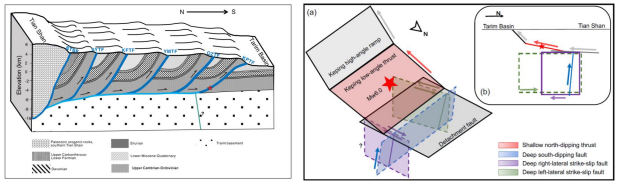
Methods and results

We combined InSAR measurements and relocated aftershocks to investigate the faults responsible for this earthquake. Tests of different fault models show that the combination of a shallow thrust fault and two deeper faults can best reconcile the surface deformation and aftershock distribution. Stress analysis suggests that slips on the shallow fault reactivated the older basement structures at depth.



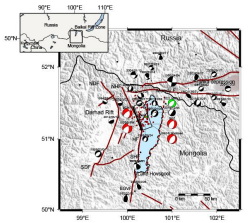
Tectonic implications

Our results reflect the basement-involved shortening activated by a thin-skinned thrust faulting event with the deformation implying the basin-ward orogenic process of the southwest Tian Shan.



2021 Mw6.7 Hövsgöl, Mongolia earthquake

Introduction

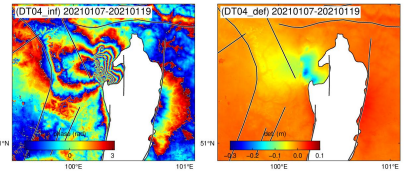


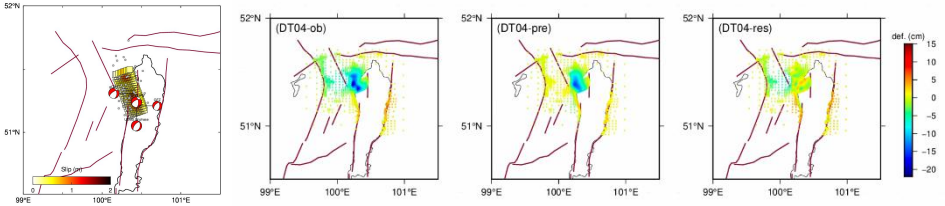
2021 Mw6.7 Lake Hövsgöl earthquake occurred in the Mongolia-Baikal rift zone, which is located in the northern tip of the Asian tectonic region, which is bounded by the Tibet Plateau orogenic belt and the Siberian Platform. This region is one of the active tectonic region of the India–Eurasia collision with lots of rift and graben structures.

Observations and results

We collected Sentinel-1 SAR images spanning the earthquake from descending DT04 track and extracted the surface deformation field for this event. Combining the LOS deformation field and previous geological studies, we suppose that the causative faults of this event is the North Hövsgöl Fault on the west bank of the Hövsgöl Lake.

Using the Bayesian inversion method we derived a fault plane with two slip patches, one is mainly strike slip and the other is mainly normal slip component. The correlation between the observed and predicted displacements by the single fault model is 97.46%.





Coulomb stress changes

This event has a triggering effect on the western segment of the Tunka Fault and Mondy Fault to the north. Since the catastrophic M8+ earthquakes in 1905, no large earthquakes have occurred in this region, thus the attention should be paid to the seismic risk on adjacent faults.

Conclusions

- InSAR provides us with an opportunity to study areas with sparse seismic data.
- The moderate Intra-continental dip-slip earthquakes occur in the orogen and rift zones can also be complex.
- Such blinded dip-slip earthquakes raise concerns for seismic risk and illuminate the deformation and evolution of the continental structures.

Data and Resources

The interferograms were obtained using the Sentinel-1 Interferometry Processor, which is developed by the Radar Imaging Geodesy Group at Peking University. The software package is designed for large-scale InSAR processing with Sentinel-1 TOPS images.

References

- He,Y.Q., Wang, T., Fang, L.H., & Zhao, L. (2021). The 2020 Mw6.0 Jiashi earthquake: Coinvolvement of thin-skinned thrusting and basement shortening in shaping the Keping-tage fold-and-thrust belt in southwestern Tian Shan. ***Seismol. Res. Lett***. Accepted for publication.
- He,Y.Q., Wang, T., & Zhao, L. (2021). The 2021 Mw6.7 Mongolia earthquake. In prepare.