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Editorial: InSAR for volcanoes and tectonics

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Editorial on the Research Topic
InSAR for volcanoes and tectonics

InSAR has revolutionized the way scientists can measure the Earth's surface deformation since its ability to produce maps of surface motions over wide areas with high spatial resolution is still unparalleled. The recent improvements in satellite technologies, computing and methods mean that InSAR has now become a standard monitoring technique to study volcanoes, geothermal areas and earthquakes. Overall this Research Topic has collected original papers based on InSAR observations, models and technical advances for studying active volcanic, geothermal and tectonic areas worldwide.

At active volcanoes, the magmatic processes linked to the migration of magma toward the surface, the inflation and deflation cycles of magma chambers, and also hydrothermal activity are probed with InSAR. Ducrocq et al. used InSAR and GPS to study Hengill, a volcanic and geothermal area at the triple junction between two rifts and a transform segment in south Iceland. The authors observed both uplift and subsidence with different spatio-temporal characteristics, possibly caused by both magmatic and hydrothermal processes. An uplift signal with 10-km diameter of up to 12 mm during a 5-month period was observed without any significant increase in seismicity, borehole temperature or pressure. At the same time, a smaller (5-km diameter) subsidence occurred just a few km's west of the uplift. The authors explain the subsidence as shallow (~1–2 km) depth, pressure decrease due to fluid extraction from the geothermal plant. The uplift is instead modeled with a pressure increase at 6–7 km depth, but whether the pressurization is due to magma inflow or hydrothermal fluids remains elusive. Currently, independent geophysical data are needed to interpret geodetic measurements in geothermal areas and achieve a realistic understanding of subsurface processes.

Trasatti et al. used InSAR L-band data to study the vegetated Changbaishan volcano (China and North Korea), showing that the volcano is currently active and experiencing a phase of uplift during 2018–2020. The authors explain the deformation with magma inflow in a volcanic plumbing consisting of a system of stacked-sills as well as a creeping normal fault on the south-west flank of the volcano. The study demonstrates that deformation from stacked-sill magma systems might be measured with geodetic techniques.

In seismic regions, InSAR maps of steady, sudden and transient fault motions enable researchers to improve knowledge of seismogenic faults and to evaluate seismic potential during the earthquake cycle. Feng et al. used InSAR measurements and models together with Coulomb stress changes to infer the geometry of the seismogenic fault that caused the Ms 6. 6 Jinghe earthquake (Tianshan, China) in 2017. The results show that InSAR is important as the Jinghe earthquake did not produce a rupture at the surface and the seismogenic fault was debated. Feng et al. show that InSAR and seismicity indicate that the seismogenic fault is the Jinghenan Fault and not the Kusongmuxieke Piedmont Fault as previously believed.

Zhang et al. integrated InSAR and GPS to calculate the high-resolution three-dimensional velocity field over a ~1,000 km long, left-lateral Ganzi-Yushu-Xianshuihe Fault system in eastern Tibet. The Ganzi-Yushu-Xianshuihe Fault is one of the most seismically active faults in China, where the Mw 6.9 Yushu earthquake occurred in 2010. The authors used a vast InSAR dataset from nine Sentinel-1 tracks between 2014 and 2020 together with GPS to show that the slip rates vary along different segments of the fault system. Along the Ganzi-Yushu Fault slip rate increases from 1 mm/yr to 6 mm/yr from north-west to south-east, and along the Xianshuihe Fault slip rate increases from 8 mm/yr to 12 mm/yr. Furthermore, the velocity field was explained assuming both continuous and block-like models for different fault segments.

Methodological advances continuously arise in InSAR, such as new methods to overcome the limitation of loss of coherence due to deformation gradients exceeding one fringe per pixel. This typically occurs in the vicinity of seismic ruptures, eruptive craters and fissures and sinkholes. Peng et al. developed an improved offset tracking method based on the identification of feature points (FPOT) rather than tie points with a regular spacing as done in conventional offset tracking methods (RPOT). The authors find an ideal procedure consisting of five major steps: feature points identification using the Speed Up Robust Features (SURF) algorithm, feature point masking with SRTM Water Body Data to speed up the computation, cross-correlation as in conventional offset tracking, quadtree filtering to remove outliers, and removal of orbital effects. Applications to the coseismic displacements caused by the 2016 Mw 7.8 Kaikōura earthquake in New Zealand show that offset maps obtained with FPOT have considerably lower RMSE relative to GPS than those obtained by RPOT.

Author contributions

CP wrote the first draft of the editorial. HW, AS and VD wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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