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基于InSAR同震形变观测反演2010年新西兰南岛M_w7.1 Darfield地震同震破裂分布

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Co-seismic slip distribution of 2010 Darfield, New Zealand M_w7.1 earthquake inverted using InSAR measurements

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摘要

2010年9月4日新西兰南岛Canterbury平原发生了M_w7.1地震,震源深度约为10 km.本次地震发生在一条震前不为人所知的断层上.我们利用覆盖整个震区的合成孔径雷达(SAR)观测资料,通过干涉处理分析获得雷达视线向(LOS)同震形变场;以此资料为约束反演了断层的几何参数以及同震破裂分布.结果显示,该地震造成四条相对独立断层的破裂.大部分的地震矩释放发生在Greendale断层(编号1—4),其错动以右旋走滑为主,最大破裂约为8.5 m.其它三条断层中,经过震源的逆冲断层最大破裂为5.1 m (编号6),位于Greendale断层以西的逆冲断层最大破裂为3.5 m (编号5),位于Greendale断层北面的走滑断层最大破裂为1.9 m(编号7).反演的Greendale断层地表滑动与地质调查得到的地表破裂在形态和数值上均吻合较好.本次地震释放的地震矩为5.0×10^{19}N·m,矩震级为7.1.板块边界带形变场分析表明,Darfield地震的发生受边界带应变分配在该地区残留构造应力场控制,其复杂性体现了区域构造应力场的特点.地震对其周围地区的应力场影响较大,库仑应力增加区与余震分布有一定对应关系,并在2011年Christchurch 6.3级地震发震断层区域造成约0.1bar的库仑应力增加,对此地震有一定的触发作用.

关键词 Darfield地震, InSAR, 同震破裂, 库仑应力

Abstract:

The 2010 Darfield M_w7.1 earthquake occurred on a previously unknown fault zone, which absorbs only a minor portion of relative plate motion between the Pacific and Australia plates there. We attempt to obtain detailed information about fault geometry and rupture distribution of this event using InSAR data. Combining geological field survey observations with SAR displacement fringes, correlation, and range and azimuth offsets, we identify four faults which slipped during co-seismic rupture, of which seven segments are distinguished with various strikes and dip angles. Our inversion results show that the slip is concentrated in the upper 10 km depth. Slips along the Greendale fault (including four segments) are predominantly dextral with a maximum up to 8.5 m. The fault coinciding with the earthquake hypocenter slipped reversely up to ~5.1 m. The third fault located west of the Greendale fault also reversely ruptured, with a peak of ~3.5 m. Slip on the fourth fault located north of the Greendale fault and east of the second fault is minor, no more than 1.9 m. We also compare the top 1 km slip along the Greendale fault with surface rupture distribution, and find very good agreement between the two. The maximum surface slip is about 6 m, located about 26 km east of the west end of the fault surface rupture. The total seismic moment release is 5.0×10^{19}N·m, equivalent to an M_w=7.12 event. Main features of InSAR data are well recovered, the residuals near the epicenter are less than 20 cm, confirming good data fitting of our fault slip model. Based on this fault slip model we calculate about 1 bar of Coulomb stress change at the hypocenter of the 2011 M_w6.3 Christchurch earthquake, located about 30 km east of the Darfield earthquake.

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