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地震的"序列归属"问题与ETAS模型——以唐山序列为例

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ETAS model applied to the Earthquake-Sequence Association (ESA) problem：the Tangshan sequence

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摘要

历史上发生过强震地区的余震活动可能持续较长时间,而余震序列在何时可被看作正常的"背景地震活动",即"序列归属"问题在地球动力学和地震物理中有重要意义.时-空"传染型余震序列"(ETAS)模型可分离"背景"地震和"丛集"地震,并用概率形式表示作为相应事件的可能性,为考察此问题提供了可能.本文以1976年唐山M_S7.8地震序列为例,对唐山地区1970年以来的M_L4.0以上地震进行了时-空ETAS模型拟合,并以2010年以来发生的3次M_S4.0以上地震为例讨论了它们的"序列归属"问题.研究结果显示,3次M_S4.0以上地震的背景地震概率分别为0.72、0.88和0.76,表明它们作为1976年唐山M_S7.8的余震的可能性较低,更可能为背景地震.

关键词 余震, 时-空传染型余震序列模型(ETAS模型), 时间相依的地震危险性, 1976年唐山地震

Abstract:

Aftershock sequence can last a long time in the vicinity of historical strong earthquakes, especially in the mid-continental regions where deformation rate is low. The earthquake-sequence-association (ESA) problem, that is, whether an earthquake in these regions, long after the mainshock, can be associated with the aftershock sequence, or it is a ‘normal’ background event, is important in the assessment of time-dependent seismic hazard. For investigating this problem, a candidate tool is the space-time epidemic-type aftershock sequence (ETAS) model, which separates seismicity into ‘background’ and ‘clustering’ represented by probability. Taking the 1976 Tangshan M_S7.8 earthquake sequence as an example, we applied the space-time ETAS model to the seismicity in the Tangshan region since 1970, with magnitude no less than M_L4.0, and discussed the ESA problem of three earthquakes with magnitudes above M_S4.0 occurring since 2010. The ETAS model gives relatively high background probabilities of 0.72, 0.88 and 0.76, for these three earthquakes, indicating the probabilities that they are triggered by previous events, including the 1976 Tangshan M_S7.8 mainshock, are small.

Keywords Aftershock sequence, ETAS model, Time-dependent seismic hazard, the 1976 Tangshan earthquake

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