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Pre-earthquake MBT anomalies in the Central and Eastern Qinghai-Tibet Plateau detected by a wavelet-based two-step difference method

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Abstract

In recent years，thermal anomalies prior to large and hazardous earthquakes have been extensively detected by microwave remote sensing techniques. To detect robust pre-earthquake thermal anomalies buried by the complex background and frequently variant meteorological noise, we propose a wavelet-based two-step difference (WTSD) approach which incorporates hierarchical clustering and wavelet decomposition, adopting it on the 17 years' microwave data collected by AMSR-E and AMSR-2 sensors. Targeting at exploiting the association of thermal anomalies to earthquakes in terms of timing, spatial patterns and magnitudes, comprehensive statistical analysis on the pre-earthquake microwave brightness temperature (MBT) anomalies of 103 destructive earthquakes with Ms ≥ 5.0 in the Central and Eastern Qinghai-Tibet Plateau (90° – 102° E, 28° – 38° N) is conducted. Interestingly, an NE trending MBT increase stripe has been repeatedly occurring prior to 60 of the 103 earthquakes (accounting for 58.25%). Then, we conduct comprehensive statistics on the occurring time, spatial patterns and intensities of the MBT anomalies, and find them closely associated to seismic events with Ms ≥ 5.0 occurred in the Bayan Har and Qiangtang blocks. Preliminary mechanistic analysis suggests that the pre-earthquake MBT anomalies are consistent with spatial distribution of the NE-oriented normal faults and geothermal activities in this region. The pre-earthquake thermal anomalies may be caused by intensified extrusion of the Indian plate to the Eurasian plate and the increased crustal stress in this area.

(submitted to RSE, 2nd review)

Data Processing and Results

Study Area

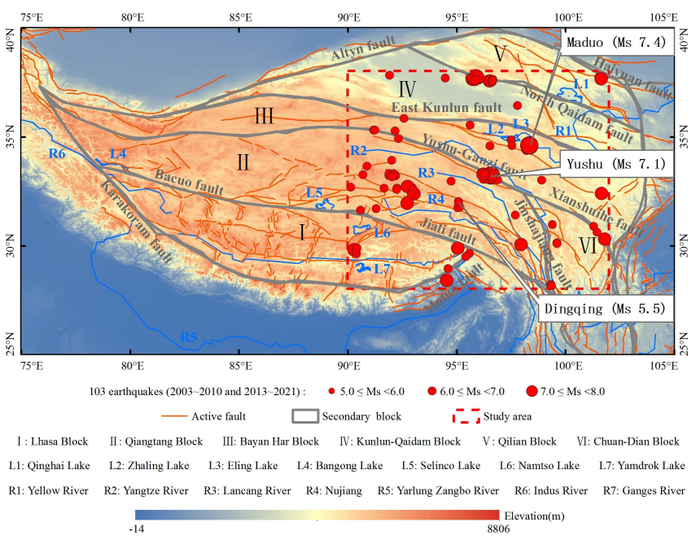

Fig.1 Topography of the Study Area

Spatial-temporal evolution of the MBT anomaly

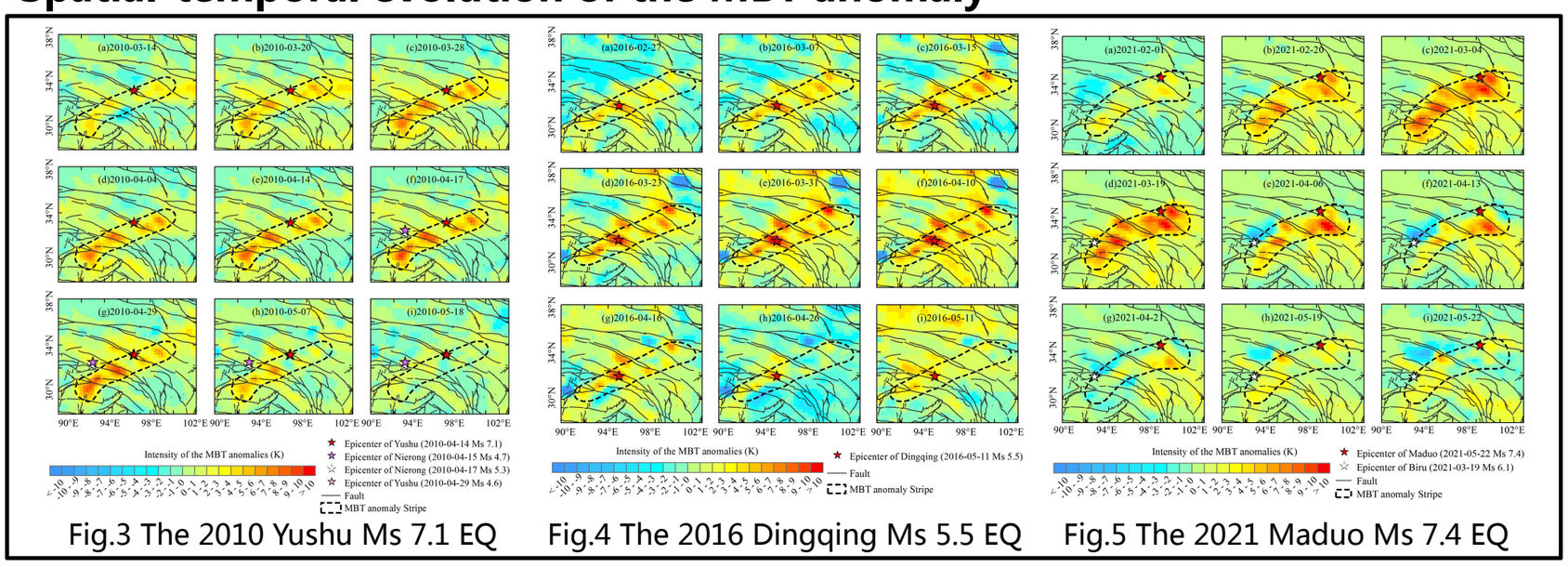

Fig.3 The 2010 Yushu Ms 7.1 EQ　Fig.4 The 2016 Dingqing Ms 5.5 EQ　Fig.5 The 2021 Maduo Ms 7.4 EQ

Methodology

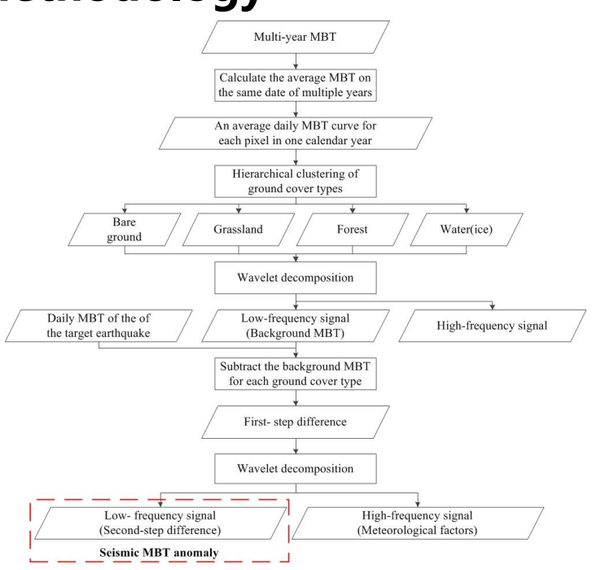

Fig.2 Work flow of the WTSD method

Association of the MBT anomalies to seismicity

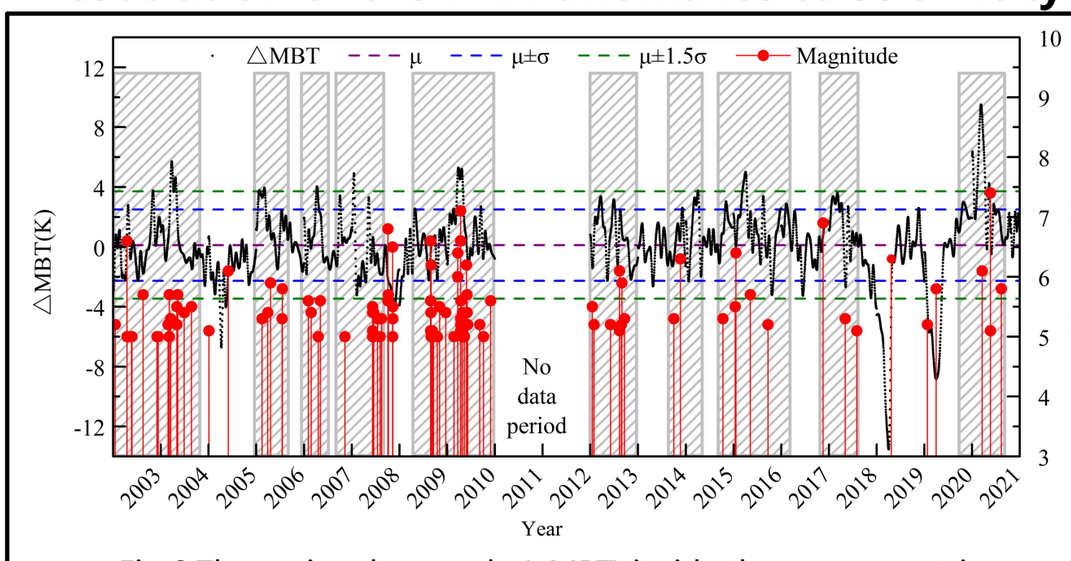

Fig.6 The regional anomaly (△MBT) inside the common stripe

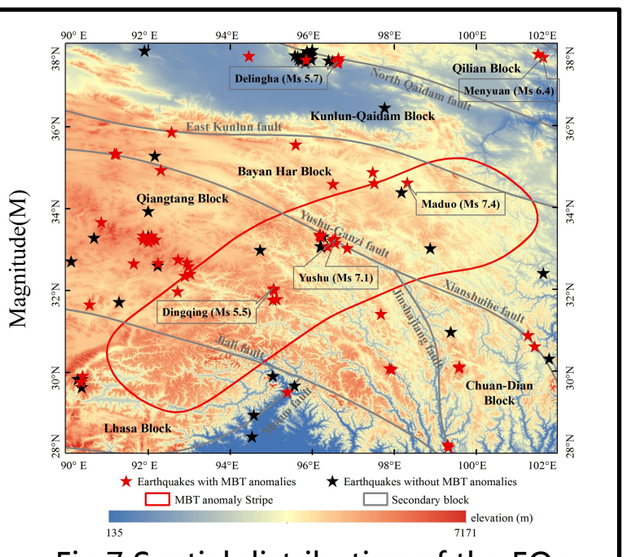

Fig.7 Spatial distribution of the EQs

Possible source mechanism of the seismic MBT anomalies

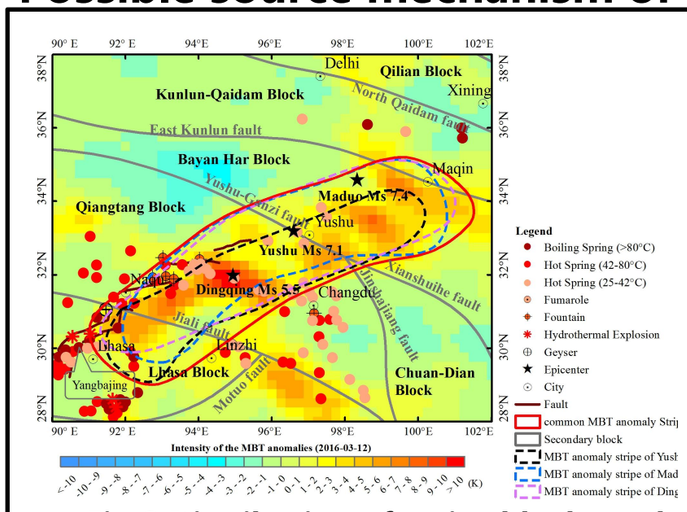

Fig.8 Distribution of active blocks and geothermal resources

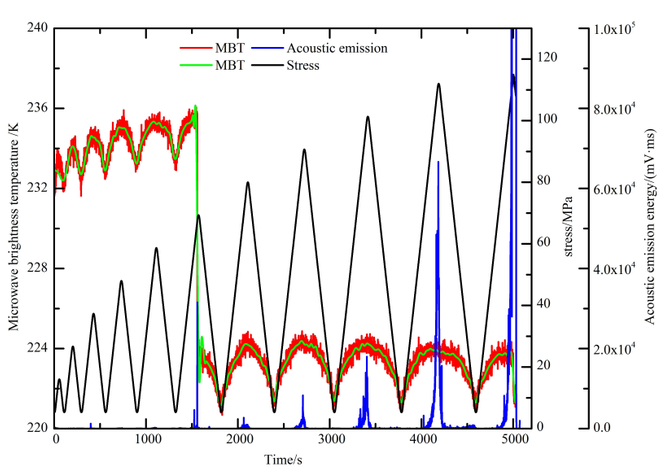

Fig.9 MBT variation during rock loading experiments

Conclusions

(1)The proposed WTSD is able to detect robust pre-earthquake MBT anomalies buried by complex background and frequently variant meteorological conditions, benefiting from the hierarchical clustering and wavelet decomposition strategy.

(2)The statistical results have demonstrated the association of the MBT anomalies to earthquakes in terms of timing, spatial pattern and seismic magnitudes.

(3)We speculate the detected NE trending MBT anomaly stripe is closely associated to the geothermal activities in this area and the increased crustal stress prior to strong earthquakes, which indicates its significant potential as earthquake precursor in the Central and Eastern Qinghai-Tibet Plateau.

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