EPISODIC OCCURRENCE, STRONG EARTHQUAKE CLUSTERING AND FAULT SYNCHRONISATION AS REVEALED THROUGH STRESS TRANSFER MODELS

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Introduction

Earthquakes are associated with faults, which constitute discontinuities in the part of the lithosphere that is assumed to maintain elastic properties. The continuous plate motion loads the faults and fault segments that are located along the plate boundaries, for example, and the resulted accumulated strain will culminate in slip onto the fault surfaces. Given that the plate motion is considered stable, the strain loading and release is expected to be regular in time, unless these fault segments are not expected to follow the stick and slip stages completely independently. Earthquakes in a sequence generally are not independent (Scholz, 1990). This implies that slip on one segment seems to "load" or "unload" adjacent segments, and thus their earthquake recurrence cannot be independent. This suits the observation that earthquakes do not usually repeat at regular time intervals, a deviation in the concept of "seismic cycle".

Stress Interaction

Interaction between faults is studied with calculating the changes in their associated stress field. The first achievements in Landers earthquake sequence prove that Coulomb stress calculations might provide a powerful tool for assessing the interaction between strong events and main shocks with their aftershocks. Convincing evidence is furthermore found between Coulomb stress changes and seismicity rate variations for several years after strong earthquakes occurrence. It appears that static stress changes as low as 0.1 bar can affect the locations of aftershocks (Harris, 2000 and references therein). This value is just a fraction of the stress drop during earthquakes, which is one reason that Coulomb stress changes are said to 'enhance' or 'encourage' the occurrence of an earthquake, as opposed to generating the earthquake. The apparent ability of stress changes that are orders of magnitude smaller than earthquake stress drops to alter seismicity rates or to promote or inhibit moderate or large earthquakes can be explained if the influenced faults are highly prestressed and the stress changes advance or retard their failure times (Gomberg *et al*., 2000). The actual triggering of earthquakes does not only depend on the actual Coulomb stress change but also on other factors including the status of the receiver fault with respect to its earthquake cycle. For example, for a fault in its early interseismic period, the Coulomb stress changes may not be sufficient to trigger the next earthquake.

Calculations of Coulomb stress changes were firstly performed for several cases of vertical strike–slip faults, given that this faulting geometry facilitated the presentation and interpretation of the spatial distribution of these stress changes. Calculations of the evolving stress field were performed in the North Aegean area, Greece, dominated by dextral strike faults, by Papadimitriou and Sykes (2010) after taking into account both the coseismic slip of the stronger events and the long term tectonic loading on the major regional faults, with the stress field being calculated according to the faulting type of the target fault resulted to effectively predicting the locations of future earthquakes.

In the back arc Aegean region, dominated by N–S extension, relative clustering in strong earthquake occurrence alternating with relatively quiescent periods, was satisfactorily interpreted by stress transfer among the fault segments comprising in a fault population, like in Thessalia area, where a cascade occurrence of four $M \geq 6.0$ earthquakes took place that has been satisfactorily interpreted by stress transfer among the fault segments comprising in the fault population (Papadimitriou and Karakostas, 2003).

The positive Coulomb stress changes are not only located at the tips of the causative faults, but they also form off–fault lobes where the aftershock activity is expected to be triggered. Large stress increases were noticed near the crack tip, but in addition there were small stress increases on either side of the crack or about one crack away. These were the regions in which off–fault aftershocks were often seen, alike in the case of the M_w=6.4 July 26, 2001 Skyros (North Aegean, Greece) earthquake that struck the submarine western end of Northern Aegean Sea (Karakostas *et al*., 2003).

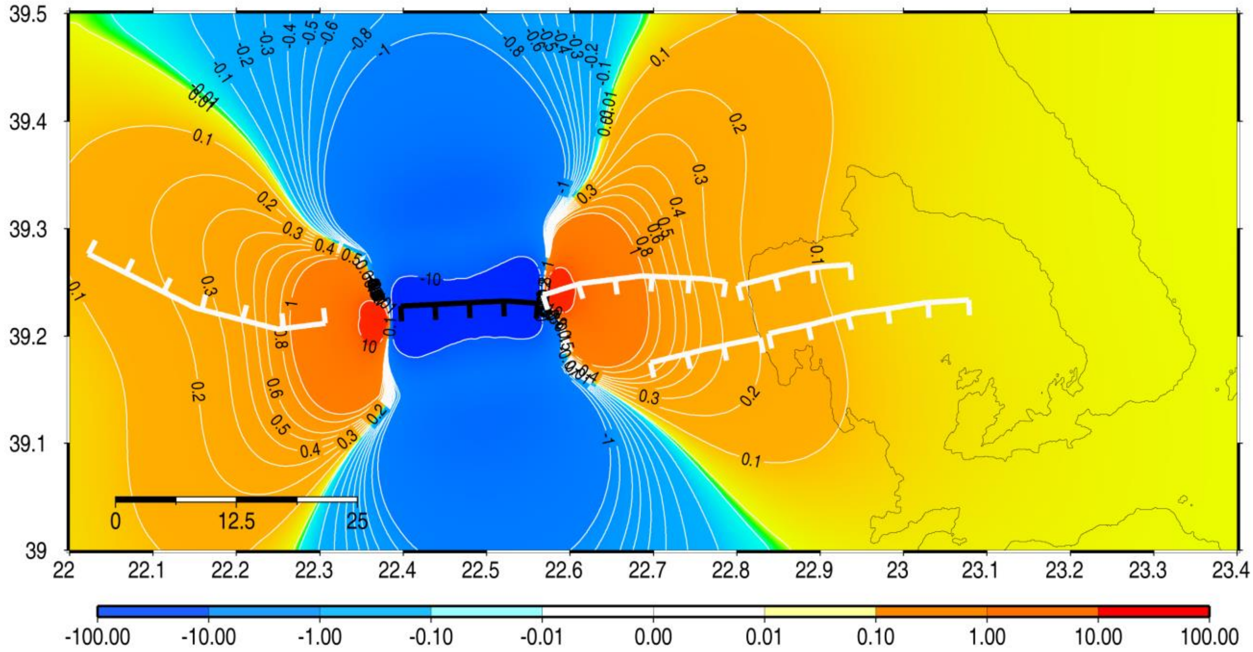

Figure 1. *Coulomb stress changes associated with the occurrence of the 1957/03/08 M6.5 earthquake in the southern margin of Thessalia basin, central Greece, calculated according to the fault plane solution of the causative earthquake, at depth of 8.0 km. Changes are denoted by colour scale at bottom (in bars). The fault traces are depicted by white lines with the ticks showing the dip direction, whereas the causative fault is shown in black (modified from Papadimitriou and Karakostas, 2003).*

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The plots were made using the Generic Mapping Tools version 5.4.4 (Wessel et al., 2013).

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