Three Approaches to Interseismic Slip Rates on the Main Marmara Fault and Their Tensorial Correlations with the Kostrov-Based Strain Rates

Volkan Özbeý, M.şahin Özeren, Pierre Henry, Elliot Klein, Gerald Galgano, Dietrich Lange, Jean-Yves Royer, Valerie Ballu, Ziyadin Çakir

Introduction

The interseismic slip distribution in the Marmara fault system represents both observational and modeling challenges. The observational challenge is obvious: the faults are under water and to understand their interseismic behavior (creeping versus locked) requires expensive and logistically difficult underwater geodetic measurements, alongside those on land. Up to now, two sub underwater studies have been conducted and they suggest that the segment to the south of Istanbul zone (so-called Central segment) is locked while some creep is probably going on along the neighboring segment to the west. Given these two important findings, the slip distribution problem is still non-trivial due to the fact that our experiments so far demonstrate that the block-based slip inversions and those that only consider a single fault (with the same geometry as one of the boundaries of the block) give significantly different results. In this study we approach the problem using three methodologies: block models with spatially non-varying strains within individual blocks, a boundary element approach and a continuum kinematic approach. Although the block model does not give spatially varying strains, the inversion results from the block model can be used as an input to model strain field in the vicinity of the fault. We construct a formulation to correlate the results from these with the strain rates obtained using focal mechanism summations.

Model Results

a) Continuum Model

General aim of this method is to minimize the following penalty function:

$$\Delta u = \sum_{i=1}^{n} \left[ \frac{1}{2} \left( \sum_{j=1}^{m} \left( u_{ij} - f_{ij} \right)^2 \right) \right]$$

where $u_{ij}$ is the observed deformation at point $(i,j)$ and $f_{ij}$ is the model deformation.

b) Boundary Element Method

The approach uses the boundary element method that employs planar triangular elements on constant displacement to model fault surfaces. In this approach, a damped least squares method is used to minimize the functional

$$\min_{\{u\}} \sum_{i=1}^{n} \left[ \frac{1}{2} \left( \sum_{j=1}^{m} \left( u_{ij} - f_{ij} \right)^2 \right) \right]$$

where $r$ is the residual, $s$ is the standard deviation, $F$ is the scaling factor just described, and $dof$ is the degrees of freedom. The sum is over all data.

c) Block Model

This approach is tried to ensure that make minimum the penalty function given below.

$$\min_{\{u\}} \sum_{i=1}^{n} \left[ \frac{1}{2} \left( \sum_{j=1}^{m} \left( u_{ij} - f_{ij} \right)^2 \right) \right]$$

where $r$ is the residual, $s$ is the standard deviation, $F$ is the scaling factor just described, and $dof$ is the degrees of freedom. The SUM is over all data.