Brief Description of the Program

1. Data Collection and Conversion into Energy Fields

The program loads all seismic events for a selected time period and converts each magnitude into seismic energy using the classical Gutenberg–Richter relation:

$$E = 10^{1.5M+4.8}.$$

Depth is included through an exponential attenuation term that reflects the decrease in stress transmitted to the surface:

$$E_{\text{eff}} = E\, e^{-d/L_{\text{depth}}},$$

where d is the depth and L_{depth} is the characteristic attenuation length.

2. Direct Stress Field (Direct Map)

For each grid node, the program computes the cumulative stress field created by all events using a Gaussian-type distance kernel:

$$K(r) = e^{-r/L},$$

and

$$S_{\text{direct}}(x) = \sum_k E_{\text{eff},k}\, K\big(r(x, x_k)\big).$$

This produces a direct map of accumulated stress, highlighting zones where energy is concentrated.

3. Inversion Map (Hidden Stress Field)

To obtain the "hidden", unreleased stress distribution, a regularized inverse problem is solved:

$$(A^\top A + \lambda I)\, s = A^\top y,$$

where

$$A_{k,i} = e^{-r_{k,i}/L}$$

is the influence matrix between events and grid nodes, y is the vector of effective energies, and s is the hidden stress field.

Tikhonov regularization suppresses noise and ensures stability. The resulting field is converted back into predicted magnitude:

$$M_{\text{pred}} = \frac{\log_{10}(S) - 4.8}{1.5}.$$

4. Time Model (Days Ahead)

Each event decays exponentially in time:

$$E(t) = E_0 \, e^{-t/\tau},$$

where τ is the temporal decay constant (typically 7 days).

For each time step t (0–30 days), the program recomputes:

- the direct map,
- the inversion map,
- new candidate stress concentration points.

The growth of predicted magnitude allows estimation of the time when a threshold event is reached:

$$t_{\text{hit}} = \frac{M_{\text{thr}} - M(t)}{dM/dt}.$$