POLE TIDE TRIGGERING OF SEISMICITY

V.L. GORSHKOV
Pulkovo observatory
St. Petersburg 196140, Russia
e-mail: vigor@gao.spb.ru

ABSTRACT. The influence of the pole tide (PT) on intensity of seismic process is searched on base of Harvard Centroid-moment tensors catalogue (CMT). The normal and shear stresses excited by PT were calculated for each earthquake (EQ) from CMT (32.3 thousands of EQ events after for- and aftershock declustering). There was revealed that there are two maxima of PT influence on weak (less 5.5 magnitudes) thrust-slip EQ near the both extrema (min and max) of shear stress. This influence has 95 % level of statistical significance by Schuster and χ^2 criteria and could explain the 0.6-year periodicity in seismic intensity spectrum. The PT influence on seismicity becomes negligible when PT variations decrease up to 100 mas. This could explain 6–7 years periodicity in seismic intensity spectrum.

1. MOTIVATION

There is periodicity of EQ intensity in PT frequency band (0.6, 1.2 and 6–7 years). The most obvious excitation factor of these EQ intensity variations is PT. But excited stress variations in the crust by PT are less 1 kPa while lunisolar tide (LST) stress variations achieve 5 kPa. Why PT can trigger EQ but it is almost impossible to reveal EQ triggering by more power LST? First of all PT is significantly powerful than LST in above-mentioned frequency band while LST is the most powerful near 0.5–1 day periodicity. Secondly the failure time t_n is depend on energy of seismic event and t_n = 1–10 years for magnitude M = 3.5–5.5 (Sadovsky, Pisarenko, 1991). That is to say preparation time t_n for weak EQ coincides with frequency band of PT induced stress variations. Thus LST are added to stress accumulation process in fault zone as powerful high-frequency noise while PT acts as systematic, nearly synchronous component for a weak EQ. At last some confirmation of the PT influence on seismic process can be found in the next papers (Levin, Sasorova, 2002; Shen, et al., 2007).

2. DATA AND METHOD

There were used 32264 EQ events from CMT (1976–2014) to search the trace of PT in seismicity after declustering for strong EQ with $M_w > 7.2$: $\Delta d(km) = 1.2exp(0.8M_w - 1.0)$ and $\Delta t(days) = 1.2exp(0.8M_w - 2.9)$. The normal and shear stresses were calculated by (Zhu, 2013):

$$\sigma_n = \sigma_n^0 \sin^2 \delta \tau_s = \tau_s^0 \sin \delta \cos \psi + 0.5\sigma_n^0 \sin 2\delta \sin \psi,$$

where $\sigma_n^0 = \tau_{\theta\theta} \cos^2 \alpha + \tau_{\lambda\lambda} \sin^2 \alpha + \tau_{\theta\lambda} \sin 2\alpha, \tau_s^0 = 0.5(\tau_{\lambda\lambda} - \tau_{\theta\theta}) \sin 2\alpha + \tau_{\theta\lambda} \cos 2\alpha$, and α, δ, ψ are strike, dip and rake angles of EQ fault plane, $\tau_{\theta\theta}, \tau_{\lambda\lambda}, \tau_{\theta\lambda}$ are element of induced by PT stress tensor. In view of free surface boundary condition (Melchior, 1978) the rest of tensor elements are equal to zero.

Phases of σ_n and τ_s were estimated for each EQ as a part between its previous and following max/min values in EQ coordinate point. EQ number N_ψ was counted in 30° phase boxes for next faulting type of EQ: normal ($-120° < \psi < -60°$), thrust ($60° < \psi < 120°$), strike-slip ($0° <\mid \psi \mid< 30°, 150° <\mid \psi \mid< 180°$) and the rest – oblique strike-slip. Schuster (1897) and χ^2 statistic tests were used for assessment of significance of phase concentration near some particular phase. Null hypothesis on random distribution of phase is rejected if probability $p_s = exp(-R^2/N_\psi) < p_{0.05}$ for Schuster and $\chi^2 > \chi^2_{0.95} = 18.307$ for χ^2 statistic test, where $R^2 = C^2 + S^2, C = \sum_{i=1}^{N_\psi} \cos \beta_i, S = \sum_{i=1}^{N_\psi} \sin \beta_i$.

3. RESULTS AND CONCLUSIONS

Approximately 90% of EQ events are indifferent to variations of Pole. The rest of events (10%) nearly repeat time variations of Pole. It is remarkable that 10% events in CMT have magnitude $M_w < 5.3$.

What are these events? PT has an influence with 95% confidence level on seismic intensity only for thrust-slip EQ with magnitude $M_w < 5.3$ ($p_s = 0.028, \chi^2 = 18.7$). Other faulting type EQ are indifferent to PT influence according to used statistic.

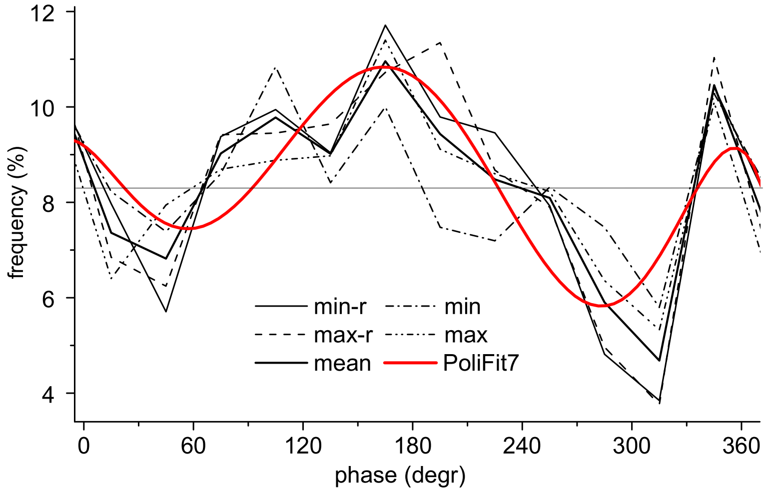

Figure 1: Various variants of frequency distribution of shear stress phases of thrust EQ. Straight line (8.3%) corresponds to even distribution of phase. Smooth red line is polynomial fitting of 'mean' line.

There are two maxima of PT influence on thrust EQ near both extrema (min and max) of shear stress (Fig. 1). This result could explain the 0.6-year periodicity in seismic intensity. The PT influence on seismicity when Pole variation damping (less than 100 mas, r in Fig. 1 denotes the data without this EQ events) becomes actually noise as it was checked by independent estimations of χ^2 and p_s. Therefore the PT is the most probable reason of 6–7 years periodicity in seismic intensity.

So we may conclude:

- Pole tide influence on seismic intensity is revealed only for thrust type of EQ with 95% reliability.
- This influence falls with rise of magnitude M and vanishes for $M_w > 5.5$.
- There are two maxima of this influence approximately coinciding with both extreme of shear stresses. This result could explain 0.6-year spectral peak in seismic intensity.
- Pole tide influence on seismic intensity for time of Pole wobble damping (< 100 mas) is actually noise. This could explain 6–7 year periodicity in seismic process.

4. REFERENCES

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