

Lunar Periodicities and Earthquakes in Italy

A technical-disclosure guide to the EqForecast model

Author: Stefano Calandra, ORCID: <https://orcid.org/0000-0001-5324-2298>



From long-term tidal modulation to short-term seismic triggering

The possible relationship between the Moon and earthquakes has long been debated in the scientific literature. Lunar–solar tidal forces are known to produce cyclic deformations of the Earth’s crust, but understanding whether and how these forces may contribute to seismic triggering requires an analysis that considers the tectonic system across multiple time scales. This study addresses the problem by examining Italian seismicity as a whole, focusing on its temporal distribution in relation to the main lunar periodicities. The analysis is based on 7,948 Italian earthquakes with magnitude ≥ 3 , recorded between 1600 and 2024. The goal is not to predict individual events, but to assess whether seismic activity shows **statistically significant and recurring patterns associated with astronomical cycles** that modulate the gravitational and tidal field acting on the crust.

The first level of analysis concerns the **lunar nodal cycles**, associated with the precession of the Moon’s orbit, with periods of approximately 9.3 and 18.6 years. These cycles produce slow but persistent variations in the geometry of the terrestrial tidal field. On these multi-decadal time scales, Italian seismicity exhibits significant oscillations in both frequency and released energy. This suggests that lunar nodal cycles contribute to modulating the long-term loading and unloading of tectonic stress on faults, defining phases in which the system approaches or moves away from critical failure conditions. Superimposed on this long-term background are shorter-term modulations linked to the **lunar synodic cycle** and **lunar declination**. Earthquakes are not randomly distributed along the lunar phase cycle: events tend to cluster preferentially around **New Moon** and **First Quarter**, while other phases show weaker or less coherent signals. This tendency is particularly evident for larger-magnitude earthquakes, indicating that certain lunar configurations are associated with an increased probability of seismic release under comparable tectonic conditions. A key result emerges from the analysis of lunar declination, which describes the Moon’s position relative to the

Earth's equator. The strongest earthquakes do not preferentially occur at maximum or minimum declination, but rather within **intermediate declination bands**. Near declination extremes, the apparent latitudinal motion of the Moon slows down and the tidal field changes only gradually over time. In these conditions, tidal forcing may be strong but relatively stable. At intermediate declinations, however, the Moon crosses terrestrial latitudes more rapidly, producing **faster temporal variations** in the tidal field and in the stress applied to fault planes.

From a seismological perspective, this distinction is crucial. A fault may remain stable even under a relatively strong but slowly varying stress, whereas it may become unstable when the **stress state is rapidly perturbed**. The results indicate that both the **amplitude of tidal forcing**, denoted by τ , and the **rate of temporal variation of the forcing**, expressed by the modulus $|\mathrm{d}\tau/\mathrm{d}t|$, can contribute to seismic triggering, depending on how close the fault is to failure. In this time scale, different lunar configurations act through complementary physical mechanisms, alternately enhancing stress stability or instability.

From lunar modulation to short-term gravitational triggering

Even shorter time scales come into play, as already explored in the first EqForecast study. On **24–48 hour windows** (Calandra & Teti, 2024)², seismic triggering is found to correlate with conditions of **stability or instability of the resultant gravitational field**, evaluated through its overall temporal variability. In this framework, stability or instability is no longer linked to a single lunar configuration, but to the dynamic behavior of the global gravitational field, which integrates the contributions of the Sun, the Moon, and the seven planets of the Solar System. The analysis that includes the full planetary system proves to be the most consistent from both a statistical and physical standpoint. It shows that the **overall variation of the planetary gravitational field**, rather than the isolated action of the lunar–solar system alone, controls the short-term dynamic equilibrium of faults. On this scale as well, it is not the absolute intensity of the forcing that is decisive, but its **temporal stability or instability**, quantified by the parameter σ^{Rf} . When a fault is already in a metastable state, such gravitational perturbations may favor the transition to rupture, converting accumulated elastic energy into seismic release.

Taken together, these results outline a coherent picture. **Lunar nodal cycles** define the long-term background level of tectonic stress; **lunar phases and declination** modulate the system on monthly scales; and **planetary gravitational stability or instability** on 24–48 hour windows acts as the immediate triggering factor. In this sense, the EqForecast model describes a true hierarchy of gravitational forcings, operating on different but physically consistent time scales. A clear conclusion follows: **the Moon does not directly cause earthquakes**. Seismic energy is accumulated through tectonic processes, while triggering depends on dynamic perturbations of the stress field generated by the combined action of multiple gravitational forcings. No single celestial body, taken in isolation, can produce an earthquake; however, the overall configuration of the astronomical system can influence **when** a critically stressed fault is more likely to rupture.

Read also:

- [Planetary gravitational forces and the triggering of earthquakes](#)
 - [Operational Features of the Pre-Seismic Alert Service \(SAP\) for Italy](#)
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Bibliographic references:

¹ **Calandra, S., & Teti, D.** (2024). Lunar Periodicities and Earthquakes in Italy. NCGT - [New Concepts in Global Tectonics Journal](#), 13 (10, december 2025), 1511–1536.

DOI: <https://doi.org/10.5281/zenodo.18075042>.

² **Calandra, S., & Teti, D.** (2024). Correlation Study: *Triggering and Magnitude of Earthquakes in Italy ($\geq M4.3$) in Relation to the Positions and Gravitational Forces of the Sun, Moon, and Planets Relative to Earth*. NCGT - [New Concepts in Global Tectonics Journal](#), 12(1), 26–52.

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