Supplementary Material

Non-linear elasticity, earthquake triggering and seasonal hydrological forcing along the Irpinia fault, Southern Italy

Stefania Tarantino[1], Piero Poli[2], Nicola D'Agostino[3], Maurizio Vassallo[1], Gaetano Festa[4], Gerardo Ventafridda[5], Aldo Zollo[4]

[1]Istituto Nazionale di Geofisica e Vulcanologia, L'Aquila, Italy

[2]Department of Goescience, University of Padova, Padova, Italy

[3]Istituto Nazionale Geofisica e Vulcanologia, Rome, Italy

[4]Department of Physics, University of Napoli, Napoli, Italy

[5]Approvvigionamento Idrico (DIRAP), Acquedotto Pugliese S.p.A., Bari, Italy

Movie S1

Text S1 – Complete derivation of poroelastic equation

Figure S1 – Velocity model, seismicity & depth sensitivity kernel

Figure S2 – Seismicity rate for varying space-temporal windows from Gardner & Knopoff

Complete derivation of poroelastic equation

Here we present the complete derivation of equation [3] in the main text.
We consider the following Cartesian system: $x = ENE$; $y = WSW$; $z = up$. Extensional stresses are considered positive. We write the poroelastic relations in a mixed-stiffnes formulation [1]:

$$\begin{bmatrix} \sigma_{xx} + \alpha P \\ \sigma_{yy} + \alpha P \\ \sigma_{zz} + \alpha P \end{bmatrix} = \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} 1-\nu & \nu & \nu \\ \nu & 1-\nu & \nu \\ \nu & \nu & 1-\nu \end{bmatrix} \begin{bmatrix} \varepsilon_{xx} \\ \varepsilon_{yy} \\ \varepsilon_{zz} \end{bmatrix}$$

where ν is the Poisson's ratio, E is the Young's modulus, α is the Biot-Willis coefficient and P is the pore pressure variation. Setting $\varepsilon_{yy} = \varepsilon_{zz} = 0$:

$$\sigma_{xx} + \alpha P = E \frac{(1-\nu)}{(1+\nu)(1-2\nu)} \varepsilon_{xx}$$

$$\sigma_{yy} + \alpha P = E \frac{\nu}{(1+\nu)(1-2\nu)} \varepsilon_{xx}$$

$$\sigma_{zz} + \alpha P = E \frac{\nu}{(1+\nu)(1-2\nu)} \varepsilon_{xx}$$

and

$$\varepsilon_{xx} = \frac{\sigma_{zz} + \alpha P}{\frac{E\nu}{(1+\nu)(1-2\nu)}}$$

Assuming that σ_{zz} (overburden stress) does not change with time and that P corresponds to a Δh change in elevation of the unconfined karst aquifer's water table and a hydraulic head change of $\rho_w g \Delta h$:

$$\Delta\varepsilon_{xx} = \frac{\alpha \rho_w g \Delta h}{\frac{E\nu}{(1+\nu)(1-2\nu)}}$$

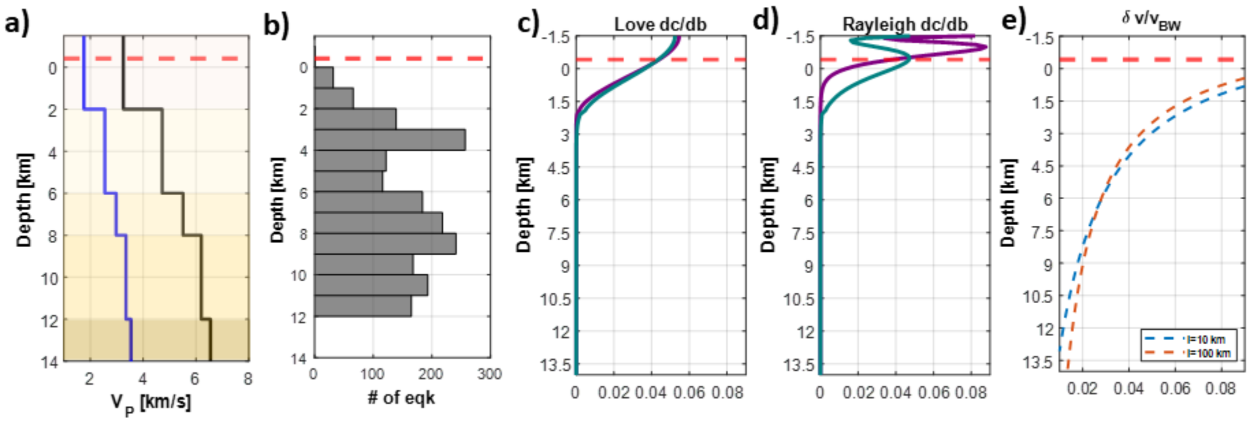

Figure S1. Velocity model, seismicity & depth sensitivity kernel: Surface waves sensitivity kernel, dashed line represent the level of Caposele Spring (417 m a.s.l) : a) P-wave (black line) and S-wave (blue line) velocity model [2] ; b) histogram of depth of earthquakes; c-d) Surface waves sensitivity kernel [3] at 0.5 Hz (green line) and at 1.0 Hz (purple line); e) Scattered body waves sensitivity kernel for coda wave time lapse 30 s for two different free paths : 10 km (blue dashed line) and 100 km (red dashed line).

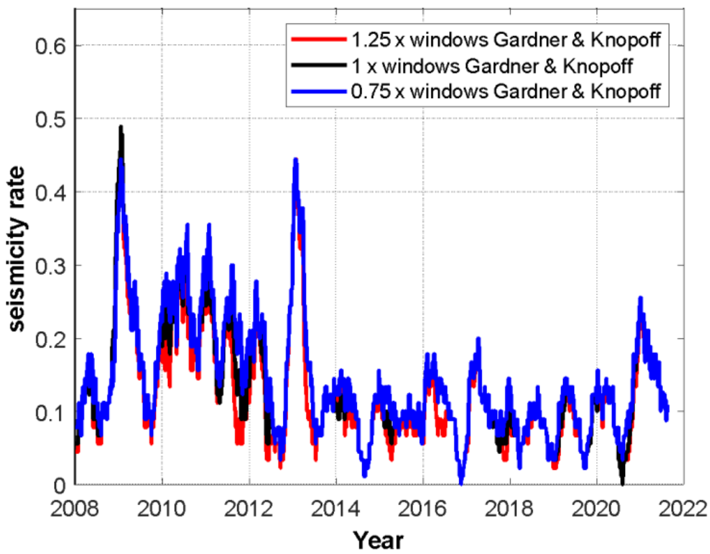

Figure S2. Seismicity rate for varying space-temporal windows from Gardner & Knopoff [4].

References

1. Wang, H. F. *Theory of Linear Poroelasticity—with Applications to Geomechanics and Hydrogeology* . (Princeton University Press, 2000).

2. Matrullo, E., De Matteis, R., Satriano, C., Amoroso, O. & Zollo, A. An improved 1-D seismic velocity model for seismological studies in the Campania–Lucania region (Southern Italy). *Geophys J Int* **195**, 460–473 (2013).

3. Herrmann, R. B. Computer Programs in Seismology: An Evolving Tool for Instruction and Research. *Seismological Research Letters* **84**, 1081–1088 (2013).

4. Gardner, J. K. & Knopoff, L. Is the sequence of earthquakes in Southern California, with aftershocks removed, Poissonian? *Bulletin of the Seismological Society of America* **64**, 1363–1367 (1974).