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Comparative kinematic synthetic study of the 2014 M_L 5.5 Orkney, South Africa, earthquake

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The 2014 M_L 5.5 Orkney earthquake

On 5 August 2014, an earthquake with M_L 5.5 occurred near a gold mine in Orkney, South Africa (figure 1). According to Moyer et al. (2017), this earthquake broke an almost vertical fault plane. The rupture started at approximately 7 km depth and it propagated mainly upward until 3 km depth. These depths are relative to the surface elevation of the local mine shaft collar (see details in Moyer et al. (2017)). The whole sequence of foreshocks, mainshock and aftershocks were recorded by a dense surface seismic network. In addition, thanks to the in-mine gold exploitation, a rather simple subsurface velocity structure is well known around the source location.

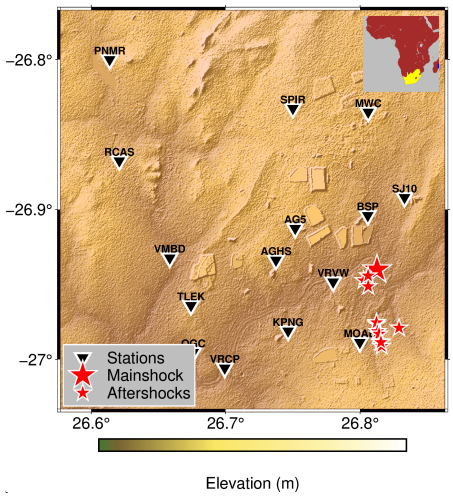

Figure 1. Map of the 2014 M_L 5.5 Orkney, South Africa, mainshock earthquake. The 15 nearest seismic stations are represented by inverted triangles. The smaller stars represent the location of the 12 largest aftershocks (magnitudes from M_L 2.0 to 2.9). The biggest star represents the main event epicentral location.

The seismic source characterization is crucial in seismology in order to better understand and unveil the physical processes behind earthquakes. Several strategies and methodologies have been developed to try to reconstruct the time-space history of an earthquake source from the analysis and inversion of seismic recordings and/or surface displacements. However, most of the times large differences between resulting models (coming from different strategies) exist for a given earthquake. These important differences highlight the immense size of the space of "possible" solutions (i.e. the null space) and the large uncertainties that a given resulting model might have. In addition, epistemic uncertainties might impact and bias these resulting models.

Goals

Given its rather simple configuration, the 2014 Orkney earthquake provides an excellent scenario to test different source modeling strategies as well as to explore associated limitations and uncertainties. The goal for this M1 internship will be to explore only two different forward modeling approaches. We will model synthetic seismograms at the 15 station locations using the forward modeling approaches from Caballero et al. (2021) and Sánchez-Reyes et al. (2018).

The student will learn how to:

- build an earthquake source model
- prepare the Green functions
- compute synthetic seismograms
- determine source model limitations
- compare synthetic seismograms using two different strategies

The work developed during this M1 internship will be only a first step in a series of systematic comparisons between two different strategies of seismic source modeling (Caballero et al., 2021; Sánchez-Reyes et al., 2018). The next steps will be devoted to perform the inversion of the seismic recordings and the assessment of the associated uncertainties.

References

Caballero, E., Chounet, A., Duputel, Z., Jara, J., Twardzik, C., and Jolivet, R. (2021). Seismic and aseismic fault slip during the initiation phase of the 2017 mw= 6.9 valparaíso earthquake. *Geophysical research letters*, 48(6):e2020GL091916.

Moyer, P. A., Boettcher, M. S., Ellsworth, W. L., Ogasawara, H., Cichowicz, A., Birch, D., and van Aswegen, G. (2017). Call for models—a test case for the source inversion validation: The 2014 ml 5.5 orkney, south africa, earthquake. *Seismological Research Letters*, 88(5):1333–1338.

Sánchez-Reyes, H. S., Tago, J., Métivier, L., Cruz-Atienza, V., and Virieux, J. (2018). An evolutive linear kinematic source inversion. *Journal of Geophysical Research: Solid Earth*, 123(6):4859–4885.