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Seismicity driven by transient aseismic processes: Detection and statistical modeling

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It is widely accepted that the Coulomb failure stress variations are underlying earthquake activity. Usually two components of stress variations are considered, the slow and stationary stress build-up due to tectonic forcing and static stress changes related to earthquake occurrences. In this case, the epidemic-type aftershock sequence (ETAS) model has been shown to describe successfully the spatiotemporal evolution of the statistical properties of seismicity. However, in many cases, seismicity might be locally dominated by stress changes related to transient aseismic processes such as magma intrusion, fluid flow or slow slip events which are not directly observable in general. Therefore, it is important to account for those potential transients, firstly to avoid erroneous model fitting leading to biased forecasts and secondly to retrieve important information about the underlying transient processes. In this work, we apply a recently developed methodology to identify the time-dependent background-term which is based on iteratively applying a ETAS-based declustering where the size of the internally applied smoothing filter is set by the Akaike information criterion. This procedure is shown to work well for synthetic data sets. We find that the estimated model parameters are biased if the time-dependence is not taken into account. In particular, the alpha-value describing the magnitude-dependence of the trigger potential can be strongly underestimated if transients are ignored. Low alpha-values have been previously found to indicate swarm activity which is often related to transient processes. Thus observed anomalous alpha-values might refer to transient forcing rather than to differences in the earthquake-earthquake trigger mechanism. To explore this, we apply the procedure systematically to earthquake clusters detected in Southern California and to earthquake swarm data in Vogtland/Western Bohemia. We identify clusters with significant transient forcing and show that low alpha-values are not always artificial and thus might indicate a mechanically different earthquake-earthquake interaction mechanism.