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Sounds of the deep subduction zone plumbing system: modeling non-volcanic tremor activity in a fault-valve, pore-pressure diffusive system

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The activity of slow-earthquakes in subduction zones have been closely linked to fluid circulation processes — like hydro fracturation and pore-pressure pulses — on the one hand by geological observations and on the other hand by slow-earthquake triggering and interaction models. In deep fault zone environments, where slow slip events and various regimes of tremor are observed, fluids coming from metamorphic dehydration of slab sediments are channeled towards the surface. Geological observations indicate that fluid transport conditions vary significantly on short time scales, and along dip, strike and width of the fault zone. In homogeneously permeable systems where fluids transit under stable conditions, pore-pressure can be described by a diffusion equation. We use a time and space bimodal description of the transport properties to model a tremor generating, permeable fault zone. Thin zones of low permeability acting as valves are distributed along the 1D channel with a higher background permeability. When a threshold pore-pressure differential is reached, the valve permeability is brought to background levels, until the barrier is healed and closes again. In this model, the opening of a valve occurs at the same time as the source of a low-frequency earthquake (LFE) is triggered. In such a set up, sources interact uniquely due to the channeling of stress through pore-pressure diffusion, and the interaction characteristics in time/space are described in the framework of a diffusive system. When the number of sources is high, the model can reproduce clustering behaviours observed for LFE activity in subduction zones. The transition from a Poisson process description of seismicity to highly clustered, cascading events is governed by the source interaction distances, directly relating to the transport properties of the medium. In time, such a model is meant to diagnose the transport conditions in a subduction zone or a magmatic system, provided that it can be characterized by clustering statistics on the low-frequency seismicity it generates.