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Slow Slip Events in Cascadia: evidences of chaotic behavior from geodetic position time series

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Slow Slip Events (SSEs) are episodic slip events that play a significant role in the moment budget along subduction megathrust. They share many similarities with regular earthquakes. In some regions, SSEs show some striking regularity, suggesting that it might be possible to forecast their size and timing. The recurrence time of SSEs is much shorter than that of regular earthquakes, giving us the possibility to study multiple cycles and test the predictability of SSEs. Here we focus on the Cascadia region, where SSEs recur every about 1 or 2 years, depending on the latitude. We study GPS position time series from 2007 to 2017, collecting a number of recurring SSEs large enough to characterize this dynamical system. We extract the geodetic signal related to SSEs via a variational Bayesian Independent Component Algorithm (vbICA), and we perform a linear inversion to derive the spatio-temporal evolution of slip along the megathrust. The results show a clear segmentation with a few major patches interacting with one another, a behavior that recalls that of a discrete body system. Thanks to Takens' embedding theorem, the knowledge of the slip temporal evolution on every patch makes it possible to derive a shadow of the attractor in the phase space of the dynamic system. It is also possible to evaluate the dimension of the attractor, and the corresponding Lyapunov exponents. The knowledge of the maximum Lyapunov exponent is important for the determination of the predictability of the system, since it determines at what rate two trajectories in the phase space diverge. The analysis reveals a low-dimensional chaotic system rather than a stochastic non-linear system. In other words, the SSEs in Cascadia can be described as a deterministic, albeit chaotic, system rather than as a random process. As SSEs might be regarded as earthquakes in slow motion, regular earthquakes might be similarly chaotic and predictable.