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Using Covariant Lyapunov Vectors to Build a Physical Understanding of Spatiotemporal Chaos in Rayleigh-Bénard Convection[1] MU XU, MARK PAUL, Virginia Tech — We explore the high-dimensional spatiotemporal chaos of Rayleigh-Bénard convection using covariant Lyapunov vectors. We integrate the three-dimensional and time dependent Boussinesq equations for a convection layer for very long-times and for a range of Rayleigh numbers. We simultaneously integrate many copies of the tangent space equations in order to compute the covariant Lyapunov vectors. We explore chaotic dynamics with a fractal dimension of nearly 50 and we compute over 150 covariant Lyapunov vectors. Using the Lyapunov vectors we quantify the hyperbolicity of the dynamics, the degree of Oseledec splitting, and explore the temporal, spatial, and spectral dynamics of the Lyapunov vectors. Our results indicate that the dynamics undergoes a hyperbolic to non-hyperbolic transition as the Rayleigh number is increased. Our results yield that all of the Lyapunov vectors computed have near tangencies with neighboring vectors. A closer look at the vectors suggests that the dynamics are composed of physical modes that are connected with tangled spurious modes that extend to all of the covariant Lyapunov vectors we have computed.

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