Vector-Valued Spectral Analysis of Complex Flows

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We apply a recently developed framework for spatiotemporal pattern extraction called Vector-Valued Spectral Analysis (VSA). This approach is based on the eigendecomposition of a kernel integral operator acting on vector-valued observables (spatially extended fields) of the dynamical system generating the data, constructed by combining elements of the theory of operator-valued kernels for multitask machine learning with delay-coordinate maps of dynamical systems. A key aspect of this method is that it utilizes a kernel measure of similarity that takes into account both temporal and spatial degrees of freedom (whereas classical techniques such as EOF analysis are based on aggregate measures of similarity between "snapshots"). As a result, VSA has high skill in extracting physically meaningful patterns with intermittency in both space and time, while factoring out any symmetries present in the data. We demonstrate the efficacy of this method with applications to various cases of complex turbulent flows.