Data-adaptive Harmonic Decomposition and Stuart-Landau closure modes

*Dmitri Kondrashov[1,2]

1. University of California, Los Angeles, 2. Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia

Novel signal processing technique will be presented that estimates power and phase spectra of mutivariate dataset via data-adaptive modes obtained in time-embedded phase space. The key feature of the Data adaptive Harmonic decomposition (DAH) method relies on the construction of covariance matrices that exploit cross correlations differently than in Principal Component Analysis and Multichannel Singular Spectrum Analysis. Eigenmodes associated with DAH covariance matrices form an orthogonal set of oscillating data-adaptive harmonic modes (DAHMs) that come in pairs and in exact phase quadrature for a given Fourier frequency, aka *sine* and *cosine.*

The recent Multilayer Stochastic Model (MSM) framework introduced in [Kondrashov, Chekroun and Ghil, 2015] emphasizes the ubiquitous role of nonlinear, stochastic as well as memory effects for the derivation of data-driven closure models with good skill in simulating and predicting main dynamical features of the targeted spatiotemporal field as an output of a high-end geophysical model, or as a set of observations. However, if the input data are not numerous enough and exhibit mixture of different spatiotemporal scales, the analysis may reveal multiple predictors and complex model structure. The DAH decomposition provides an attractive data-adaptive alternative via multilayer stochastic Stuart-Landau models (MSLM), which reduce the data driven modeling effort to elemental MSMs stacked per frequency with fixed and much smaller number of coefficients to estimate. In particular, the pairs of data-adaptive harmonic coefficients (DAHCs), obtained by projecting the input dataset onto DAHMs, can be effectively modeled within a universal parametric family of simple nonlinear stochastic models - coupled Stuart-Landau oscillators stacked per frequency, and driven at all frequencies by the same noise realization. DAH-MSLM results for climate modeling and prediction will be presented.

Keywords: stochastic inverse modeling, climate prediction, data-adaptive decomposition

