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Building Statistically Independent subspace sources of the Sea Surface Temperature Variability

Carlos Pires (1) and Abdel Hannachi (2)

(1) Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, Portugal, (2) Department of Meteorology, Stockholm University, Stockholm, Sweden

Complex climatic interactions lead to observed signals to be a nonlinear mixing of different physical and dynamical processes working as hypothetical stochastically independent sources. Their separation, by robust methods is quite relevant for the understanding and statistical modeling, particularly of the SST variability, whose source separation is performed here. A common separation technique is the Independent Component Analysis (ICA), looking for maximally non-Gaussian distributed scalar sources among orthogonally rotated pre-whitened data. However, the issuing 'independent components' (ICs) are not optimally extracted when sources are multidimensional and span a nonlinear manifold. To surpass this difficulty, a method of building independent subspaces is tested and applied. For that, we use a tensor invariant proxy of the multivariate negentropy, given by a linear combination of Frobenius norms of the joint cumulant tensors. By solving a particular high-order SVD problem, that non-Gaussianity measure is decomposed into positive parcels whose sorting and statistical testing allows for detecting the non-Gaussian data subspace and correspondent spanning ICs. However, ICs may still be nonlinearly correlated. Therefore, those ICs whose cross negentropy, associated to nonlinear links, surpass a certain maximum threshold test of statistical independence are then grouped together forming a multidimensional source. The method is then applied to the leading 12 PCs (50% of explained variance) of a series of 102 years of SST monthly anomalies equatorward of 65º. The non-Gaussian space has a dimension 5 (out of 12) meaning that much of the variability (spanning 7 dimensions out of 12) is statistically undistinguishable from non-Gaussianity. The leading most negentropic mode: IC1 (out of 5) represents El Niño conditions combined with a negative Pacific Decadal Oscillation (PDO), positive North-Pacific Gyre Oscillation (NPGO), and composite impacts of El Niño (asymmetric with respect to La Niña) on oceanic mid-latitudes, poleward of 30º. IC2 reveals a loading map mostly projecting onto the Atlantic Niño as well as on the Atlantic Multidecadal Oscillation (AMO) pattern. IC3, reflects the tendency of Central Pacific El Niños during the negative phase of AMO. IC4, combines several EOFs and the last component, IC5, is dominated by EOF10, being positive when the SSTA field in the South Pacific exhibits a zonally oriented dipole. All ICs are basically independent combinations of PC extremes and suggest independent responses of the SST field to different forcings. Only IC2 appears to be significantly isolated from the other components. The remaining components have some statistical links dominated primarily by the non-Gaussian dyad (IC1, IC5), possibly associated with the sharing of the NPGO effect, via PC4, among those ICs.

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