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Synchronous motions galore across the instrumental record

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The dynamical status of the climate system is largely unknown, as is that of its elaborated GCMs, which are not normally used for conceptual clarifications with a view on qualitative dynamics. This poses challenges when grasping the system's past evolution and/or evaluating forecasts of its future. Climate sensitivity, and complexity of free motions and response one faces in its time series, are borne in the dynamical status. Complex, evolving modal structures may emerge under multiple cyclic forcing in such a feedback system with rich oscillatory capabilities. Unstable periodic orbits (UPOs) may become manifest in the data due to episodic or persistent, internal or external synchronization. The "monsoon climate" of a small GCM, which shows a route to planetary scale chaos under active participation of the hydrological cycle, calls for clarification of the role of such type dynamics in the real climate system.

Low-dimensional behavior of a high dimensional system cannot arise without internal synchronizations. These should be detectable from representative time series. To assess (quasi-)cyclic motions and their 'coalitions' at a variety of timescales, the adaptive Matching Pursuit (MP) approach to data analysis has been chosen. One of its interesting features is the concise quantification of modal structures in terms of "structure books". In order to find sparse approximations of present-day climate dynamics, a large overcomplete dictionary has been used that is exclusively made of a very flexible analyzing wavelet, the frequency modulated (FM) Gabor atom or "Gaussian logon". The paper summarizes an exploratory, strictly univariate time series study of the instrumental period at yearly resolution, illustrates the system's traverse through different dynamic regimes, and synthesizes externally and internally synchronized multivariate motions at global, regional, and river basin scale.

Among the types of synchrony at global scale, phase–frequency ('interdomain') coalitions dominate, i.e. frequency drift of one oscillator in parallel to the phase evolution of another one (maybe even in one and the same time series). Methods of data analysis as commonly used in climate research do not uncover this sort of organized motion. Specifically, interdomain synchronies galore are found as apparent response to phase evolutions of centennial and multidecadal modes of both insolation and the system's thermal evolution, which might help separating their signatures. Further types of organized dynamics are outlined. Since only leading MP modes are used in this synthesis attempt, one may speak of an organized climate system with substantial hints at low-dimensional behavior. This justifies sparse MP approximation, bears the chance to identify (and quantify via MP structure books) the dynamical status of the system's major controls, and may contribute this way to prediction.