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Dynamical properties, seasonality and extremes of Northern Hemisphere climate fields

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Atmospheric dynamics appear to be constrained to a finite-dimensional phase space, i.e. a strange attractor. The dynamical properties of this attractor are difficult to determine due to the complex nature of atmospheric motions. A first step to simplify the problem is to focus on specific observables – here sea-level pressure, 2-m temperature, and precipitation frequency. We make use of recent advances in dynamical systems theory to estimate two instantaneous dynamical properties of the above fields for the Northern Hemisphere: local dimension and persistence. We then use these metrics to characterize the seasonality of the different fields and their interplay. We further analyse the large-scale anomaly patterns corresponding to phase-space extremes – namely time steps at which the fields display extremes in their instantaneous dynamical properties. The analysis is based on the NCEP/NCAR reanalysis data, over the period 1948–2013. We find that (i) despite the high dimensionality of atmospheric dynamics, the Northern Hemisphere sea-level pressure and temperature fields can on average be described by roughly 20 degrees of freedom; (ii) the precipitation frequency field has a higher dimensionality; and (iii) the seasonal forcing modulates the variability of the dynamical indicators and affects the occurrence of phase-space extremes. We further identify a number of robust correlations between the dynamical properties of the different variables.