Detecting regimes of the mid-latitude atmospheric circulation by nonlinear data decomposition

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We suggest a method for nonlinear analysis of atmospheric circulation regimes in the middle latitudes. The method is based on the kernel principal component analysis allowing to separate principal modes of dynamics entangled in data. We propose a new kernel function accounting specifics of large-scale wave patterns in the mid-latitude atmosphere. First, capabilities of the method are shown by the analysis of the 3-layer quasi-geostrophic model of the Northern hemisphere atmosphere: a statistically significant set of modes can be detected by the method from relatively short (several thousand days) time series. Next, we consider reanalysis data of wintertime geopotential height anomalies over the Northern hemisphere from 1950 to the present. The principal components obtained uncover several recurrent and persistent wave structures which are associated with different weather regimes. We find that there is a pronounced inter-annual and decadal variability in the dominance of different modes in different years. Possible climatic and external forcings which impact such variability as well as long-term predictability of anomalous weather seasons based on the obtained components are discussed.