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Spatial and seasonal variations of nonlinearity in the atmospheric system

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The presentation is dealing with the prospects of application of nonlinear time series analysis methods to construction of mappings between various variables of the atmospheric system. We primarily focused on comparing the results of prediction by various nonlinear methods, namely method of local linear models and artificial neural networks, to results of a linear predictive technique, represented by multiple linear regression. Our intention was to find out whether nonlinear methods can be used for constructing mappings between various climatic variables, if their use is more suitable than the linear approach, and to ascertain the geographic and seasonal distribution of detectable effective nonlinearity. Analysis was performed using time series of temperatures, pressures and geopotential heights from the NCEP/NCAR reanalysis dataset. Thanks to the quite dense spatial coverage provided by the reanalysis, we were able to create maps showing the structure of prediction errors as well as the degree of effective nonlinearity, and to identify geographic regions where nonlinear methods outperform the linear one. Some of the results were also compared to outcomes of nonlinearity tests by the method of surrogate data (which represents a more sophisticated approach than direct comparison of different methods, but also more cumbersome and with higher demands on computational power).

The results acquired so far indicate that the degree of effective nonlinearity in relationships between atmospheric variables varies significantly with both location and season of the year. Nonlinear behavior seems stronger in winter than in summer in most regions (in the northern hemisphere). Also, the observed nonlinearity is more profound in the temperate regions of both hemispheres in comparison with the tropics or the equatorial area.