Application of linear dynamical mode decomposition to surface air temperature in 20th century

Andrey Gavrilov\textsuperscript{1}, Sergey Kravtsov\textsuperscript{2}, Dmitry Mukhin\textsuperscript{1}, Evgeny Loskutov\textsuperscript{1}, and Alexander Feigin\textsuperscript{1}

\textsuperscript{1}Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russian Federation
\textsuperscript{2}University of Wisconsin-Milwaukee, Milwaukee, Wisconsin, USA

According to recent study \cite{Kravtsov2018}, the current state-of-the-art climate models lack the substantial part of internal multidecadal climate signal which is observed in the 20th century surface air temperature reanalysis data as a global stadium wave (GSW). In the presented work we further investigate this phenomenon using the recently developed method \cite{Gavrilov2018} of empirical spatio-temporal data decomposition into linear dynamical modes (LDMs). The important property of LDMs is their ability to take into account the time scales of the system evolution (they are extracted from observed dataset by the Bayesian optimization technique) better than some other linear techniques, e.g. traditional empirical orthogonal function decomposition. Like any linear decomposition, it provides the time series of principal components and corresponding spatial patterns.

We modify the initially developed LDM decomposition to make it possible to take into account a prescribed external forcing (like CO\textsubscript{2} emissions, sun activity etc.) and then find part of variability which may be considered as an internal climate dynamics decomposed into set of modes with different time scales, and hence may be helpful in GSW interpretation. The results of applying the method to the 20th century surface air temperature with different ways of forcing inclusion will be presented and discussed.