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Reduced-models of a Martian-like atmosphere over various POD bases

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The combination of the Proper Orthogonal Decomposition (POD) and Galerkin projection methods is a conceptually simple procedure to construct reduced empirical models of systems of high complexity such as a planetary atmosphere. The POD-Galerkin procedure requires the definition of a norm that determines the character of the modes that constitute the basis of the reduced phase space. For instance, if the norm is variance, the first POD basis modes are optimised for explaining variance.

An appropriate norm to model a planetary atmosphere using the primitive equations of dynamic meteorology is total energy (TE), i.e. the sum of kinetic (KE) and potential energy (PE). The phase space measured by the TE norm can be divided in two subspaces, one associated with kinetic energy and another one related to potential energy. The KE subspace is formed by the horizontal velocity components. The PE subspace is constituted by a conveniently chosen thermal variable. The phase space separation gives rise to the possibility of choosing from a variety of bases.

We present the analysis and reconstruction of the outcome of an integration of a GCM over a flat planet with simple parameterisation of physical processes. The parameters are set so that the model resembles the dynamics of the atmosphere on Mars. To perform the analysis of this dataset we try three different bases to reduce the dimension of the model using TE as a norm. The first one is determined by directly maximising the system's TE. The second is a transformation of the previous one where the KE-related variables are decoupled from the PE-related ones. The last basis is computed by performing the POD on each subspace separately. We evaluate them on the grounds of their ability to accurately represent the behaviour of the original system.