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Constraining simulated atmospheric states by sparse empirical information

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Empirical information on the state of the atmosphere before the mid-19th century is sparse and usually represents seasonal or annual means, and thus data assimilation methods used for the 20th century are not directly applicable. In this presentation three assimilation methods that have been developed during recent years to constrain the states in atmosphere models with empirical information typically available for the last few hundred years will briefly be introduced and their common aspects as well as their differences will be discussed. These methods are Ensemble Member Selection, Forcing Singular Vectors and Pattern Nudging. The first method uses ensembles of simulations and selects the members that are over a certain period closest to empirical information with respect to some cost function. Forcing Singular Vectors uses adjoint models to define small additional forcings that after a given time bring the simulated state close to a target state.

Pattern Nudging, which will be the focus of the presentation, uses simple nudging terms to control the circulation in General Circulation Models (GCMs) such that the amplitude of large-scale anomalies is close to prescribed values without suppressing synoptic-scale variability. In applications these large-scale anomalies may be obtained from proxy-based reconstructions or represent idealised situations for process studies. In comparison with the other methods Pattern Nudging needs less computing resources as it does not require ensemble simulations or adjoint models, which makes it particularly suitable for GCMs. Based on simulations with the atmosphere GCM ECHAM4 it will be shown that Pattern Nudging performs generally well when the aim is to control the state of the Northern Annular Mode, but that the performance varies seasonally. It will also be shown that the synoptic-scale variability responds realistically to the large-scale forcing.