P1.11 CONDENSED REPRESENTATION OF ATMOPSPHERIC DYNAMICS BY USING ITS ESSENTIAL DEGREES OF FREEDOM IN A PRIMITIVE EQUATION MODEL

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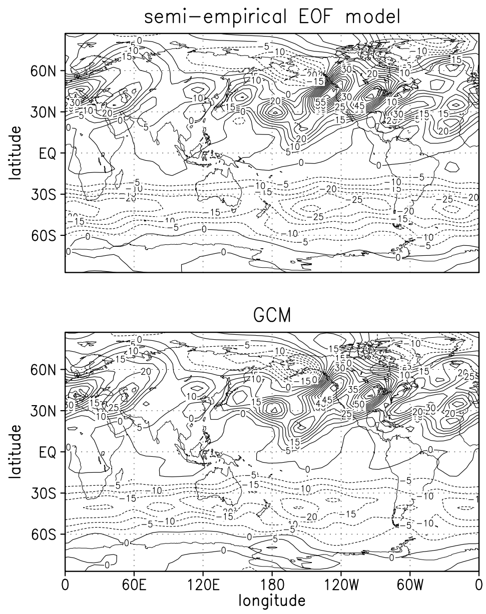

Figure 1: The january mean meridional momentum transport by the transients, projected onto the leading 30 EOFs, as simulated by the GCM, and by the 30-EOF model. Units are m^2/s^2.

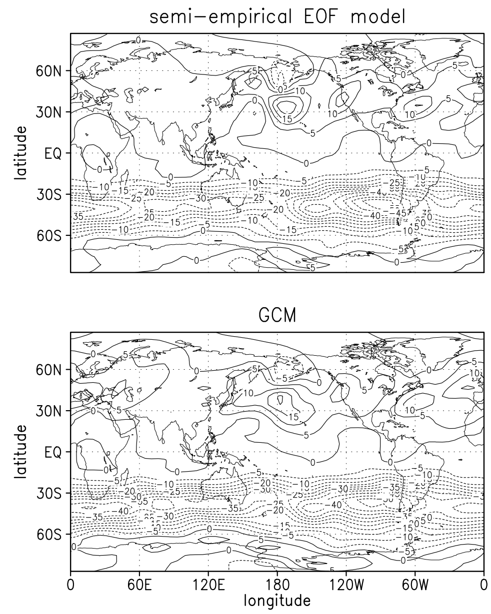

Figure 2: As Fig. 1, but for july.

Reduced models for the atmosphere use a dynamical core as realistic as possible in combination with an optimal set of basis patterns and a good parameterization of the impact of scales and processes not explicitly resolved (closure). The patterns are chosen such that they can give a rather complete description of the climate but simultaneously neglect highly improbable realizations of unrealistic states. Interest in such models can arise for several reasons. One can consider a successful reduction of the atmosphere's dynamics to its essential degrees of freedoms as an objective in itself since it provides a necessary dynamically-oriented counterpart to well-known attempts at estimating the dimension of the climate attractor by statistical means (e.g. Lorenz, 1969; Livezey and Chen, 1983; Horel, 1985; Toth, 1994, Fraedrich et al., 1995). One can also hope that a condensed representation of the behaviour of weather and climate can yield additional insights into the mechanisms controlling them. Finally, on the more technical side there is the slight hope that they could be candidates for so-called intermediate complexity climate models, nearly as realistic as general circulation models but considerably faster, and therefore a useful tool in studies of the ultra-low-frequency behavior of the climate system. This paper is a continuation of previous examinations on the possibilty of using empirical orthogonal functions (EOF) as near-optimal basis patterns. With respect to the closure problem Achatz and Branstator (1999) have shown that the empirical determination from a GCM data set of linear parameterizations of the effect of ageostrophy, unresolved vertical and horizontal scales, and unresolved physics can improve a reduced model with a quasigeostrophic

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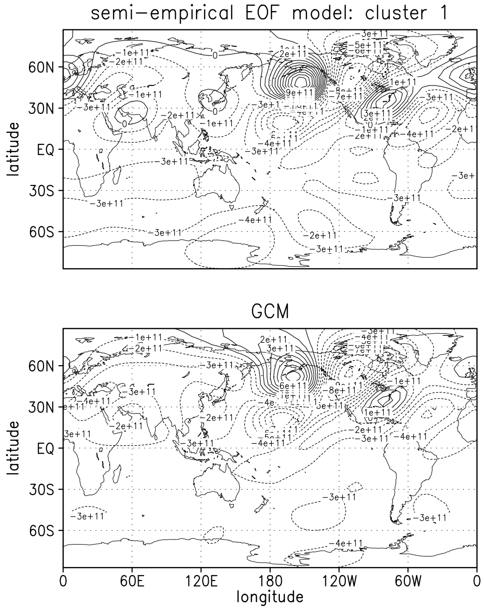

Figure 3: For the streamfunction of the surface-pressure wheighted barotropic flow-field: Anomaly with respect to the january mean state in the first cluster centroid determined in a three-cluster partition of the time-filtered january data set (low-pass filter 5d) from the semi-empirical 30-EOF model (upper panel), and from the GCM (lower panel). Units are Pa m^2/s. The percentage of GCM states in the cluster is 30%, the corresponding number for the reduced model 27%.

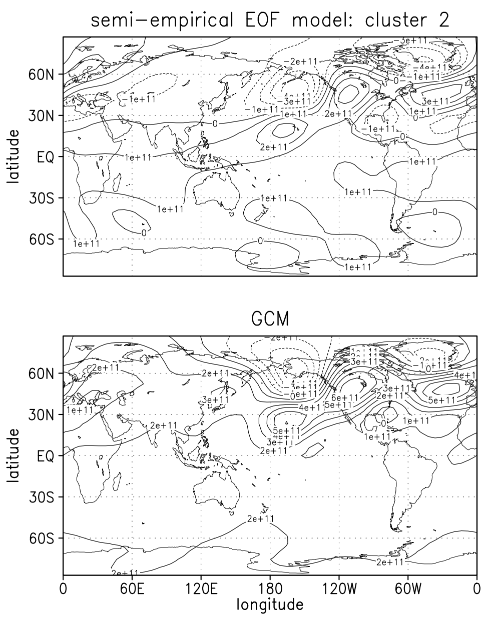

Figure 4: As Fig. 4, but for cluster 2. The percentage of GCM-states in the cluster is 40%, the one for the reduced model states is 38%.

two-layer-model core such that it is able to reproduce the internal variability of the GCM not only in mid-latitudes but also in the tropics. In order to also include the nonlinear tropical dynamics we have built on this result and developed a corresponding model class based on the primitive equations. Another novelty in comparison to previous work is the presence of a seasonal cycle in the reduced model. Comparison with the climatology of a conventional GCM (ECHAM3, Voss et al., 1998) shows good agreement. Models based on 500 and as few as 30 EOFs (extracted from GCM data by use of a new total energy metric comprising winds and temperatures on all levels simultaneously) can simulate the seasonal dependence of monthly mean states and fluxes quite well (Fig. 1 and 2).

With respect to nongaussian behaviour we find that recurrent anomalies can also be reproduced. The january data of the GCM show a significant partition into three clusters. The same is also found for the 30-EOF model. The corresponding anomalies with respect to the january mean state are very similar (Fig. 3-5).

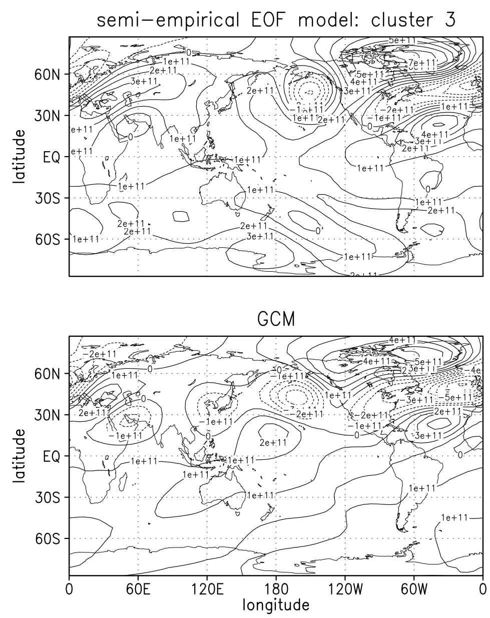

Figure 5: As Fig. 4, but for cluster 3. 30% of all GCM states are in this cluster, and 35% of all analyzed states from the 30-EOF model.

A study on the possibility to interprete such anomalies as steady states of the model dynamics incorporating the net effect of transients (e.g. Michelangeli et al., 1995; Hannachi, 1997) shows that this hypothesis does not agree well with the behavior observed in the data.

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